EXECUTIVE SUMMARY

ENERGY ENGINEERING ANALYSIS

of

SACRAMENTO ARMY DEPOT

for

U.S. ARMY CORPS of ENGINEERS
SACRAMENTO DISTRICT

Contract No. DACA05-81-C-0132

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LIST OF ABBREVIATIONS

BFW	Boiler Feed Water
Btu	British Thermal Unit
CEC	California Energy Commission
CY	Cubmic Yard
DHW	Domestic Hot Water
DOE	Department of Energy
ECM	Energy Conservation Measure
ECO	Energy Conservation Opportunity
EUI	Energy Usage Index (KBtu/ft^2)
FC	Foot Candle
-HP	Negative Horsepower
HVAC	Heating, Ventilating & Air Conditioning
HX	Heat Exchanger
KBtu/ft^2	Thousands of Btu's per square foot
KV	Kilovolt
KVA	Kilovolt ampere
LF	Linear Foot
MB	Mega Btu
MW	Megawatt
MWH	Megawatt Hour
PPH	Pounds per hour
SF	Square Foot
SIR	Savings Investment Ratio
SY	Square Yard
UA	Heat Loss Factor (Btu/hr °F)
Δ UA	Change in Heat Loss Factor (Btu/hr°F)

CHAPTER 1

INTRODUCTION

Reference

1.1 PURPOSE OF PROJECT

The purpose of the Energy Engineering Analysis Program (EEAP) is to provide a Basewide Energy Plan in compliance with the objectives of the Army Facilities Energy Plan (AFEP). The Basewide Energy Study provides a coordinated plan to reduce energy consumption in keeping with the long term objective of becoming as energy self-sufficient as feasible without sacrificing the mission of the Post. Vol. 1 Sec. 1.2

1.2 STUDY INCREMENTS

The Basewide Energy Plan was developed from the energy recommendations of seven different increments of work as defined by the EEAP and summarized below (full scope included in Appendix, Vol. 1): Vol. 1 Sec. 1.2

Increment A: Buildings

ECIP projects involving buildings and their contents.

Increment B: Utility Systems & EMCS

ECIP projects involving utility distribution systems, and feasibility of an Energy Monitoring and Control System (EMCS)

Increment C: Renewable Energy

Feasibility of converting energy consuming systems to solar, biomass hydroelectric, wind, or geothermal energy.

Reference

Increment D: **Cogeneration & Solid Waste**

Feasibility of installing cogeneration and heating plant solid waste, refuse derived fuel (RDF) or waste oil.

Increment E: **Boiler Plants**

Feasibility study of centralizing boiler plants or converting existing plants to solid fuel.

Increment F: **O&M/Minor Construction**

Energy Conservation recommendations for modifications and changes in system operation which are within the Facilities Engineer funding authority and management control.

Increment G: **ECIP Drop-Outs**

Feasible energy savings projects developed in Increments A and B which do not qualify under ECIP criteria.

1.3 STUDY ORGANIZATION

The detailed analysis, conclusions and recommendations of the Basewide Energy Plan are organized into the following volumes: Vol.1 Sec. 1.1

Executive Summary

Volume 1 Increments A, B, C, D, E, G
Text and Appendix

Volume 2 Programming Documents

Volume 3 Increment F and Appendix

Volume 4 Building Data Sheets

CHAPTER 2

INSTALLATION ENERGY PROFILE (FY 75-82)

2.1 DESCRIPTION OF POST

Reference

2.1.1 Location

Sacramento Army Depot (SAAD) is located 8 miles south of Sacramento, California and consists of 485 acres with 109 buildings. It is situated in an industrial area on relatively flat land at an elevation of 42 feet above mean sea level. Vol. 1 Sec. 3.1.1

2.1.2 Climate

SAAD is located in a semi-arid valley which generally has very little transition between summer and winter. Summer is characteristically hot and dry with continuously clear skies and very little precipitation. Winter is generally cold and damp with frequent rain accompanied by moderate winds. Also low ceilings and visibilities due to stratus clouds and fog often prevail for extended periods. Vol.1 Sec. 3.1.2

The 1% summer design temperature is 101°F with a wet bulb temp of 70°F and a daily range of 35°F. There are 1052 hours per year that the summer temperature is above 80°F. Percent possible sunshine for the summer is about 95%.

Winter design conditions are 29°F with annual degree days averaging 2843 and a prevailing wind of 5 knots from the ESE. Average annual precipitation is 17.2 inches and occurs primarily in the winter months. Percent possible sunshine for the winter is 62%. The annual average insolation on a horizontal surface for Sacramento is 581 KBTU/SF.

Reference

2.1.3 Mission

The mission of SAAD is to repair and modify selected electronic equipment, communication equipment and portable equipment shelters. It also provides storage for electronic equipment and cold storage of batteries. Vol. 1 Sec. 3.1.3

2.1.4 Number and Size of Buildings

SAAD has 109 buildings totalling 2,844,009 SF. This includes 302,000 SF for maintenance and production and 2,269,900 SF for storage. The remaining area is used for administration, utilities and military family housing. A summary of heated and unheated facilities is as follows: Vol. 1 Sec. 3.1.4

TABLE 2.1

NUMBER & SIZE OF BUILDINGS

	TOTAL		HEATED		UNHEATED	
	No. of Bldgs	SF	No. of Bldgs	SF	No. of Bldgs	SF
Temporary	23	53,051	17	52,394	6	657
Semi-Permanent	40	114,018	20	98,826	20	15,192
Permanent	46	2,676,940	27	1,251,428	19	1,425,512

2.1.5 Population

The depot population since FY 1975 has averaged 3,040 military, civilian government employees, contract personnel (Pan Am), and military dependents.The average population growth has been 61.4 people per year. Because of the numerous unpredictable factors effecting future population, estimates beyond 3 to 5 years are extremely unreliable. Vol. 1 Sec. 3.1.5

Reference

2.2 ENERGY SOURCES, COSTS, & DISTRIBUTION

2.2.1 Energy Sources And Costs

SAAD uses two primary sources of facility energy, electricity and natural gas. Number 2 fuel oil, which is used as a backup fuel, has not been used in recent years in the dual fired central plant boilers. Following are the source of each and their cost as of 31 December, 1982. Vol. 1 Sec. 3.2.1

TABLE 2.2

ENERGY COSTS

Energy	Supplier	Cost	$/MB
Electricity	Sacramento Municipal Utilities District Sacramento, Calif.	Winter:	
		$23.50 (Base Charge)	
		$0.0326/KWH(1st 10,000 KWH)	9.55
		$0.0151/KWH(over 10,000 KWH)	4.42
		$3.05/KW(over 30 KW)	
		Summer:	
		$23.50 (Base Charge)	
		$0.0380/KWH(1st 10,000 KWH)	11.13
		$0.0151/KWH(over 10,000 KWH)	4.42
		$3.85/KW(over 30 KW)	
Natural Gas	Pacific Gas & Electric Company Sacramento, Calif.	Schedule:	
		G-2: $0.55600/Therm	5.56
		G-52: $.52268/Therm	5.23
No. 2 Fuel Oil	None (1)	$.96/Gallon (2)	6.92

Notes:

(1) Not purchased in recent years-used only for boiler testing.

(2) Based on Dec 82 price for bulk quantity, from Energy User News.

Reference

2.2.2 Future Energy Costs

The following Table lists future energy costs as projected by the supplying utilities: Vol. 1 Sec. 3.2.2

TABLE 2.3

FUTURE ENERGY COSTS

Fiscal Year	Electrical Energy ($/MB)	% Change	Natural Gas(1) $/MB	% increase
1982	1.84	base	4.71	base
1983	2.17	+17.9	5.33	+13.2
1984	2.29	+5.5	5.95	+11.6
1985	2.54	+10.9	6.51	+9.4

(1) Approximately 80% of the natural gas used at SAAD is at rate G-52, interruptible.

2.2.3 Electrical Distribution

SAAD purchases electricity from the Sacramento Municipal Utility District (SMUD) through a 69KV aerial line that enters the post at the southeast corner. The main meter and substation are located at the center of the post (Bldg. 450). The substation consists of a 6250 KVA delta-wye providing 4160 V through a kilowatt-hour and demand meter to five air circuit breakers (one spare) then to four feeder circuits. Vol. 1 Sec. 3.2.3

Feeder No. 1 supplies Bldgs. 320, 348, 420, 423 and several smaller facilities on the west side. Feeder No. 2 provides power to the south half of the post including all 500-600 facilities and family housing. Feeders No. 3 and 4 supply power to the north portion of the post including the large warehouses, headquarters, officers club, and the reserve center.

2.2.4 Natural Gas Distribution

SAAD purchases natural gas from the Pacific Gas & Electric Company (P.G.& E.). Gas is delivered Vol.1 Sec. 3.2.4

Reference

from a 60 p.s.i. main running along Fruitridge Road (just north of post) to a metering station located north of Bldg. 149. Buildings 180 and 181 are supplied natural gas through a separate metering point north of Bldg. 180. The pressure is reduced to 8 p.s.i. at the metering station and distributed to 51 buildings and the central boiler plant. Twelve (12) sub-meters are installed on individual facilities and processes.

SAAD is billed monthly for consumption at two different rates: G-2, the commercial rate, and G-52, the interruptible rate. The central boiler plant is on interruptible gas. The gas consumption at the boiler plant is metered separately and subtracted from the main meter reading to allocate the G-52 rate.

2.2.5 Water and Sewer Distribution

SAAD purchases all water from Sacramento County and distributes it throughout the base in underground mains. Water is primarily used for processes, sanitation, irrigation and fire protection. Vol. 1 Sec. 3.2.5

Although SAAD has a waste treatment plant, the sanitary wastes are discharged to the County regional treatment plant. Industrial wastes are treated separately before discharging into the sanitary system.

2.3 CENTRAL STEAM SYSTEM

2.3.1 Central Boiler Plant

The Central Boiler Plant, Bldg. 352, was constructed in 1942 with three Wickes 289 HP water tube boilers. In 1972 these boilers were upgraded to 560 HP with new S.T. Johnson burners and electric driven induced-draft fans. In 1979 a York-Shipley 300 HP fire tube boiler was added to the plant to supply summer steam while the other three are shut down for annual inspection and maintenance. Vol. 1 Sec. 3.3.1

The boilers have dual fuel capability with number 2 fuel oil as a back-up source of energy. Six

Referen

underground storage tanks store 224,000 gallons of number 2 fuel oil.

Normal operation provides 80 psig steam year-round with possibly a shutdown on Christmas or New Years. Two Wickes boilers are used during the winter and the York-Shipley boiler is used during the summer.

2.3.2 Steam Distribution

80 psig steam leaves the central boiler plant and splits into two mains running north and south on Midway Ave. Approximately 5000 LF of pipe in underground tunnels and 8400 LF of overhead pipe serve 21 buildings. The steam presure is generally reduced (15 psig) at the entrance to each building to be used for space heating, DHW, cooking or process. Vol. 1 Sec. 3.3.2

The condensate return is a combination vacuum and pumped system. Return in the buildings is under vacuum to the receiver and then pumped from the receiver back to the central boiler plant. The condensate distribution lines parallel the steam lines. Buildings 320, 420, and 423 do not return their condensate to the system which amounts to approximately 10% of the total system demand.

2.4 INDIVIDUAL HEATING PLANTS

2.4.1 Steam Boilers

In addition to the Central Boiler Plant there are five (5) steam boilers serving individual facilities at SAAD. Their location and use are summarized in Table 2.4 below. Only one boiler in Bldg. 650 is fired at a time. Vol. 1 Sec. 3.4.1

Reference

TABLE 2.4

Steam Boiler Description

Location	Type	No. & Size (HP)	Press	Fuel	Use
245	Fire Tube	1-15 HP	12	Nat Gas	HVAC
300	Fire Tube	1-22 HP	12	Nat Gas	HVAC
555	Fire Tube	1-25 HP	15	Nat Gas	HVAC
650	Fire Tube	2-40 HP	40	Nat Gas	Heat/DHW

2.4.2 Hot Water Boilers

Building 180 and 680 have hot water boilers for domestic hot water and space heating. System descriptions are included in Volume 4, Building Data Sheets. Vol. 1 Sec. 3.4.2

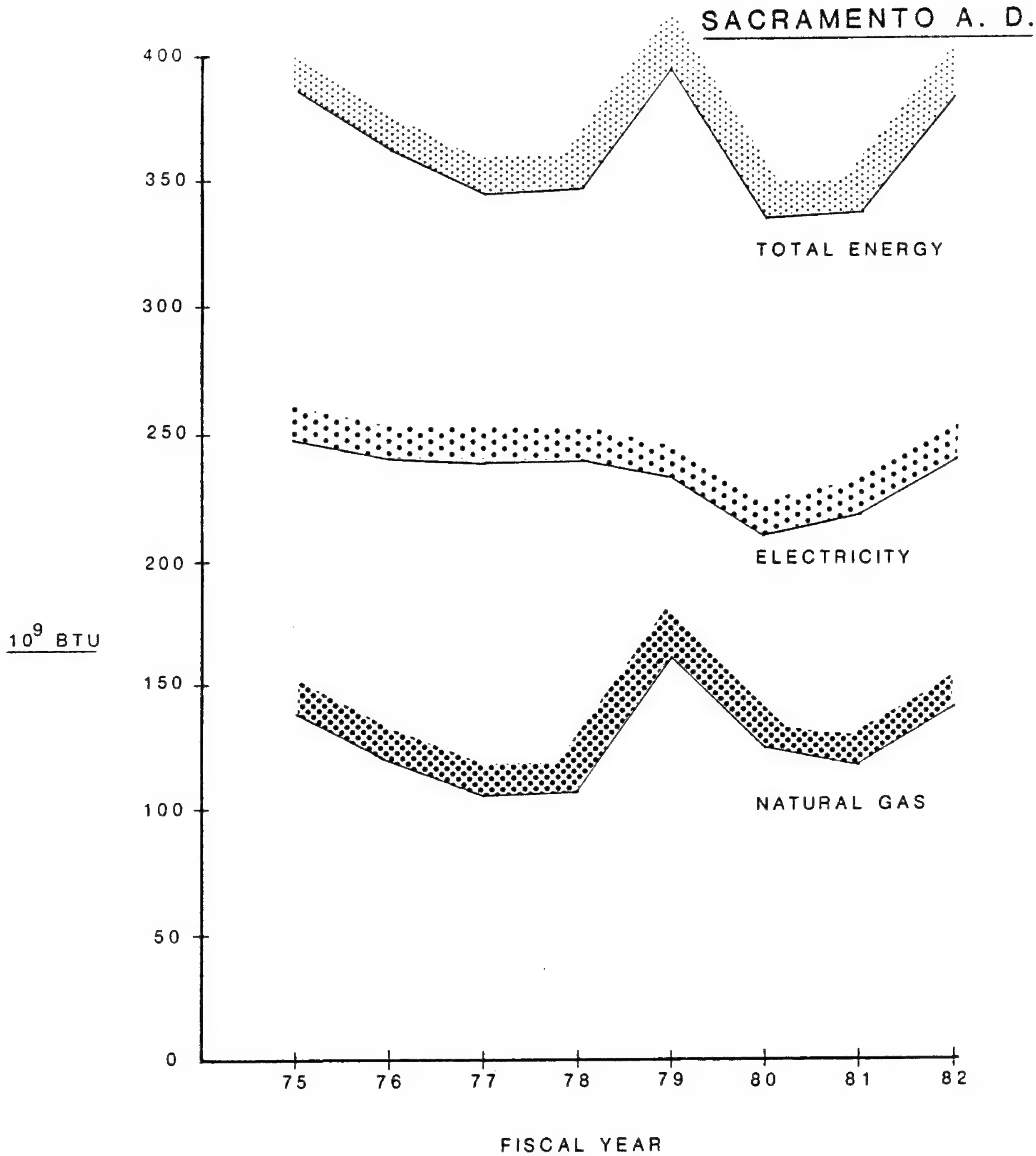
2.4.3 Gas Furnaces

Thirty five (35) buildings use direct fired heating systems including five (5) residences. These systems include gas furnaces, unit heaters and infrared heaters. Sizes and capacities (when available) are listed in Volume 4, Building Data Sheets. Vol. 1 Sec. 3.4.3

2.5 HISTORICAL ENERGY CONSUMPTION (FY 75-82)

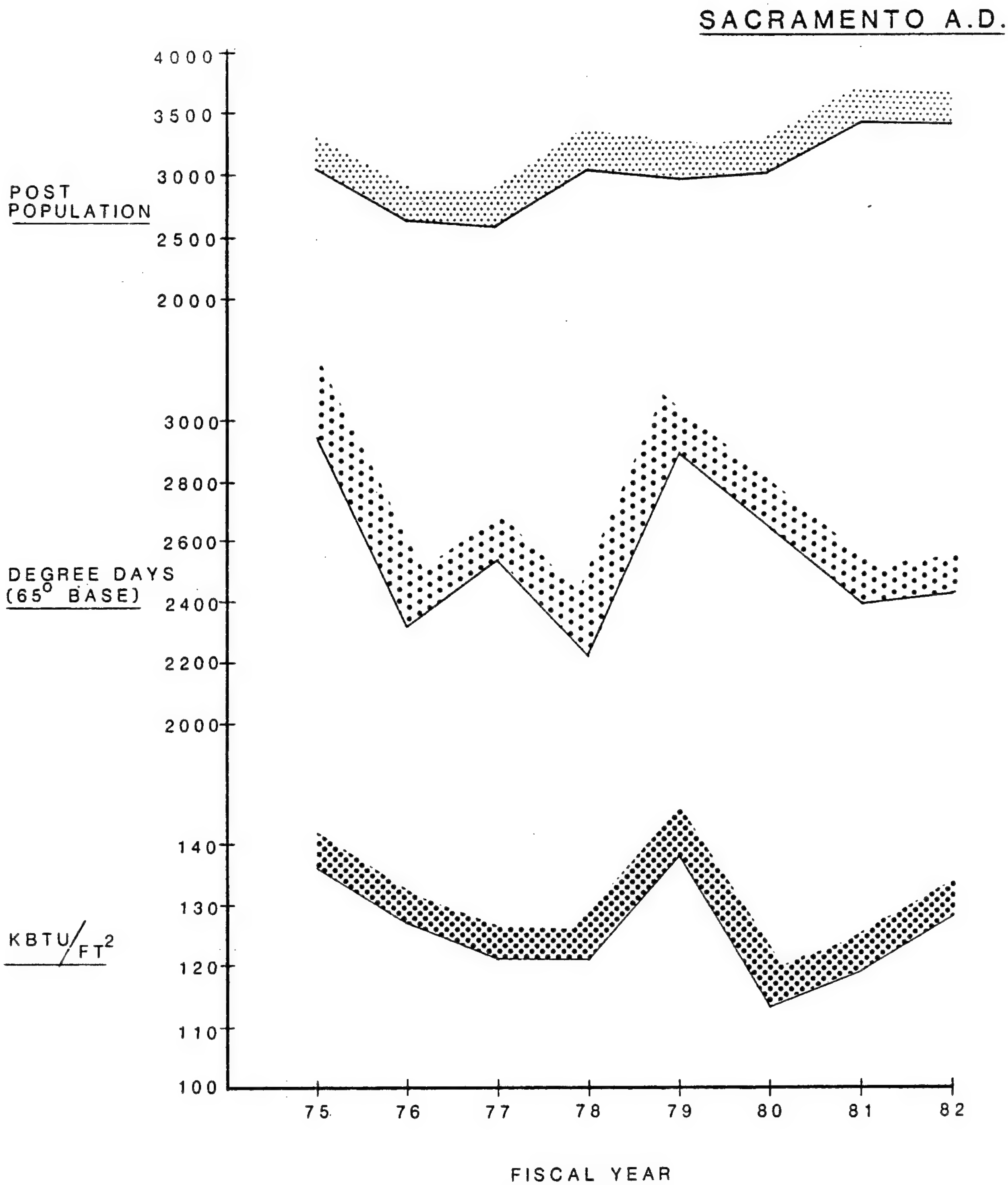
2.5.1 Total Energy

Total facilities energy consumption (without transportation fuel) decreased 13.2% between FY 75 and 81. However, the total consumption increased dramatically in FY 82 for a net decrease of only 1.6% between FY 75 and 82 (see Fig.2-1). This increase in FY 82 is suspected to be due to problems encountered while replacing a portion of the steam distributin system. Factors that may effect the annual energy consumption at SAAD are weather, population and change in building square footage or usage. The changes in these factors are depicted in Fig. 2-2. There were no significant changes in usage during the FY 75-82 period. Vol. 1 Sec. 3.5.1



ENERGY CONSUMPTION, FY 75-82

Fig. 2-1



EUI vs. DEGREE DAYS and POPULATION

Fig. 2-2

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Figure 2-2 indicates the Energy Use Index (EUI) which is the facility total energy usage divided by the square footage. This index accounts for changes in building square footage occupied. The FY 82 EUI is 5.1% below the FY 75 level. Degree days were less in FY 82 but population has increased by 11.6% since FY 75. This indicates an increase in mission workload which would result in increased energy use. We conclude that if SAAD had not realized an increase in workload, its EUI would have decreased more than 5.1%.

SAAD's FY 82 energy distribution is shown in Fig. 2-3. Vol. 1 Sec. 3.5.2

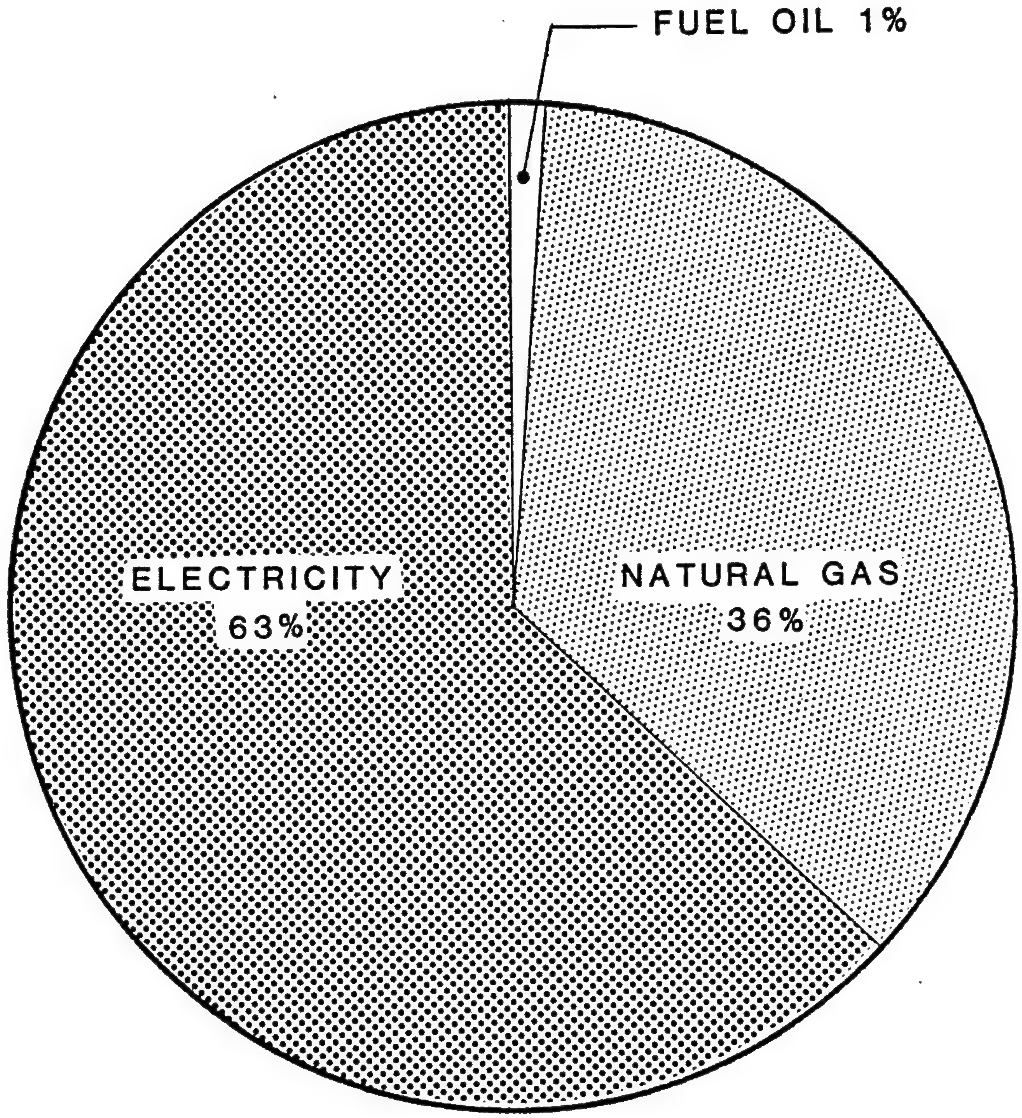
2.5.2 Electricity

Annual electric consumption has been fairly constant since FY 75 (see Fig. 2-1). 1980 consumption was 9% below 1975 followed by a 4% increase in FY 81 and 10% increase in FY 82.

The monthly electrical use for FY 80, 81 and 82 is presented in Fig. 2-4. FY 75 consumption is also provided for comparison. Consumption is expressed in megawatt hours (MWH) or thousand kilowatt hours. Demand (KW) is the highest average power requirement in any 15 minute period during the month (FY 75 data not available).

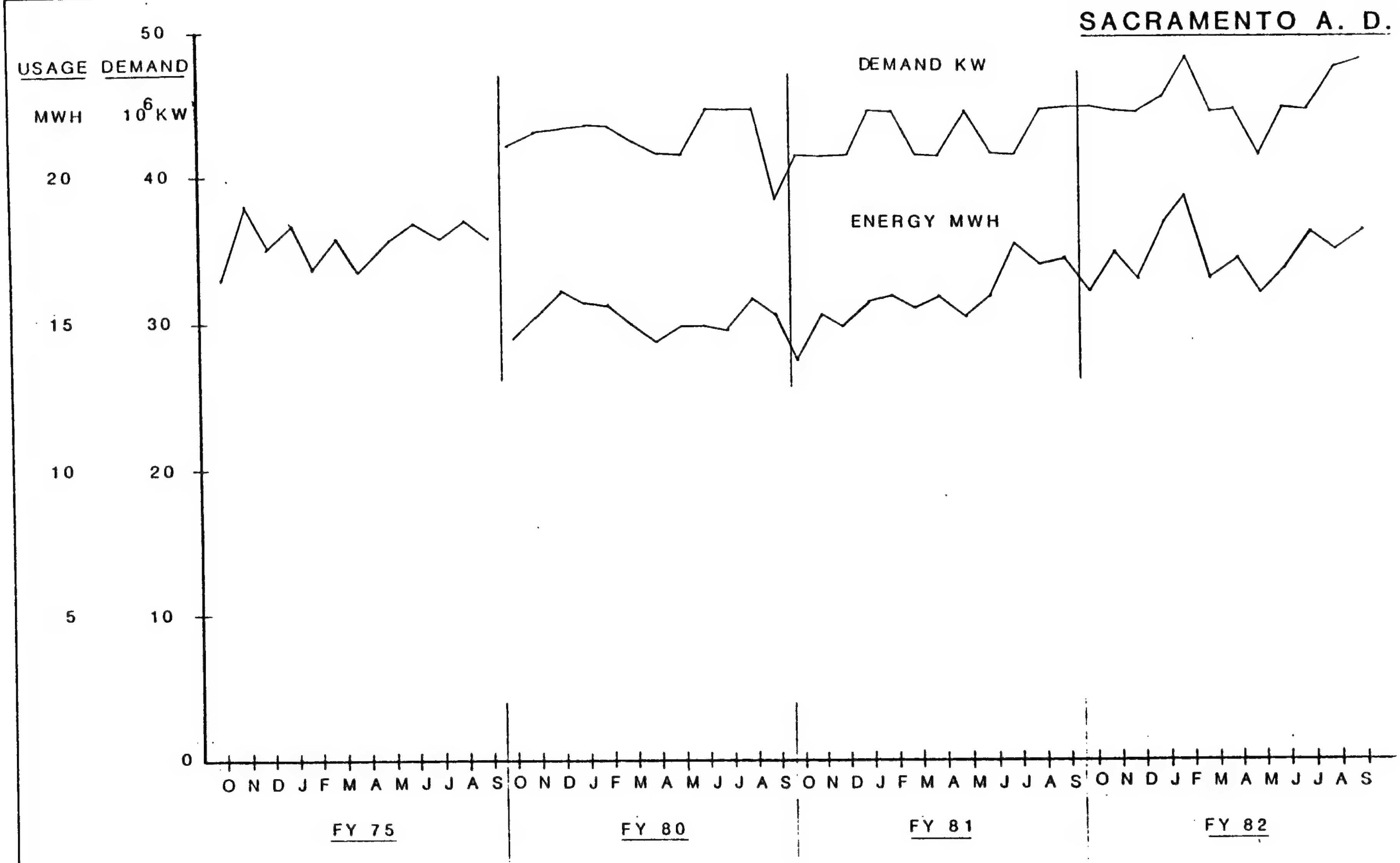
Although electrical consumption has increased 14% over the past 2 years, demand has increased only 7%. This suggests that the total connected load has remained relatively constant which means that either daily work patterns have changed or additional shifts have been added. The latter appears to be the case in light of the 11.6% increase in population discussed in the preceding section.

There is very little seasonal variation in electrical demand, which indicates that either winter electrical loads such as electric space heating are being offset by summer refrigeration loads or the seasonal loads are a very small percentage of the total. We believe that the seasonal loads are small. Most of the large air conditioning systems run the entire year.



ENERGY DISTRIBUTION, FY 82

Fig. 2-3



MONTHLY ELECTRICAL USAGE & DEMAND FY 80, 81 & 82 vs. FY 75

Fig. 2-4

Reference

Figure 2-5 shows the weekday electric profile at SAAD. There is a sharp increase in demand from 5AM to 8AM when most of the equipment and lights are turned on. The daily peak occurs at 11 AM or 1 PM with a noticeable decrease during the lunch hour. Consumption falls off rapidly at 3 PM and again at 11 PM. This base load is attributed primarily to equipment operating in Bldgs. 245, 300, 320, 420, 425 and 555.

Figure 2-6 shows the weekend electrical profile of SAAD. There is some activity between 5AM and 4PM on Saturday but the rest of the time is fairly constant at 1500 KW.

2.5.3 Natural Gas

Since FY 75, natural gas consumption has been fairly constant with variations due primarily to weather. Figure 2.7 indicates the annual consumption and heating degree days (HDD). HDD are an indication of the severity of winter temperatures and thus the energy requirement for space heating. The increase in FY 79 consumption can be partially attributed to the weather. Vol. 1 Sec. 3.5.3

The relationship between monthly gas consumption and HDD is illustrated in Fig. 2-8. The space heating demand is zero during the summer months so natural gas consumed during this period is for processes, cooking, DHW, and boiler and steam distribution losses. This base load is constant through the summer and is assumed to be constant during the winter. The base load of 5200 MBTU/mo accounts for nearly 50% of the total consumption.

2.6 ENERGY BALANCE

2.6.1 Energy Consumption by Building Type

Figure 2-9 shows the total energy consumed by the various types of buildings in FY 82. Buildings were broken into 7 basic types: Administration, Housing, Warehouses, Community Activities, Electrical Repair, Industrial, and Boiler Plants. See Table 1.1 in Volume 1 for complete building list and designation of building type. Individual energy consumptions for each building Vol. 1 Sec. 3.6.1

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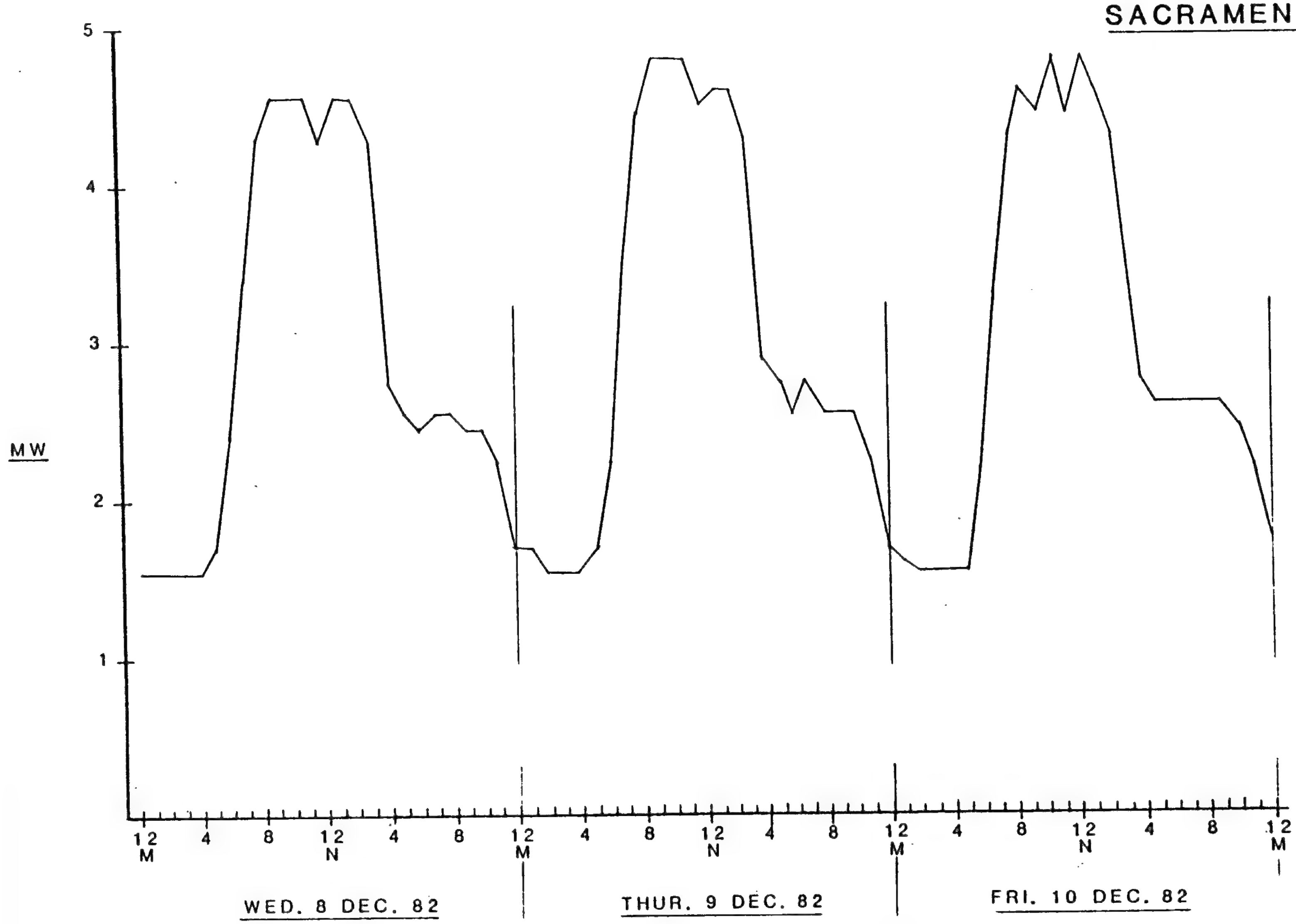

ELECTRICAL DEMAND PROFILE FOR WINTER WEEKDAYS

Fig. 2-5

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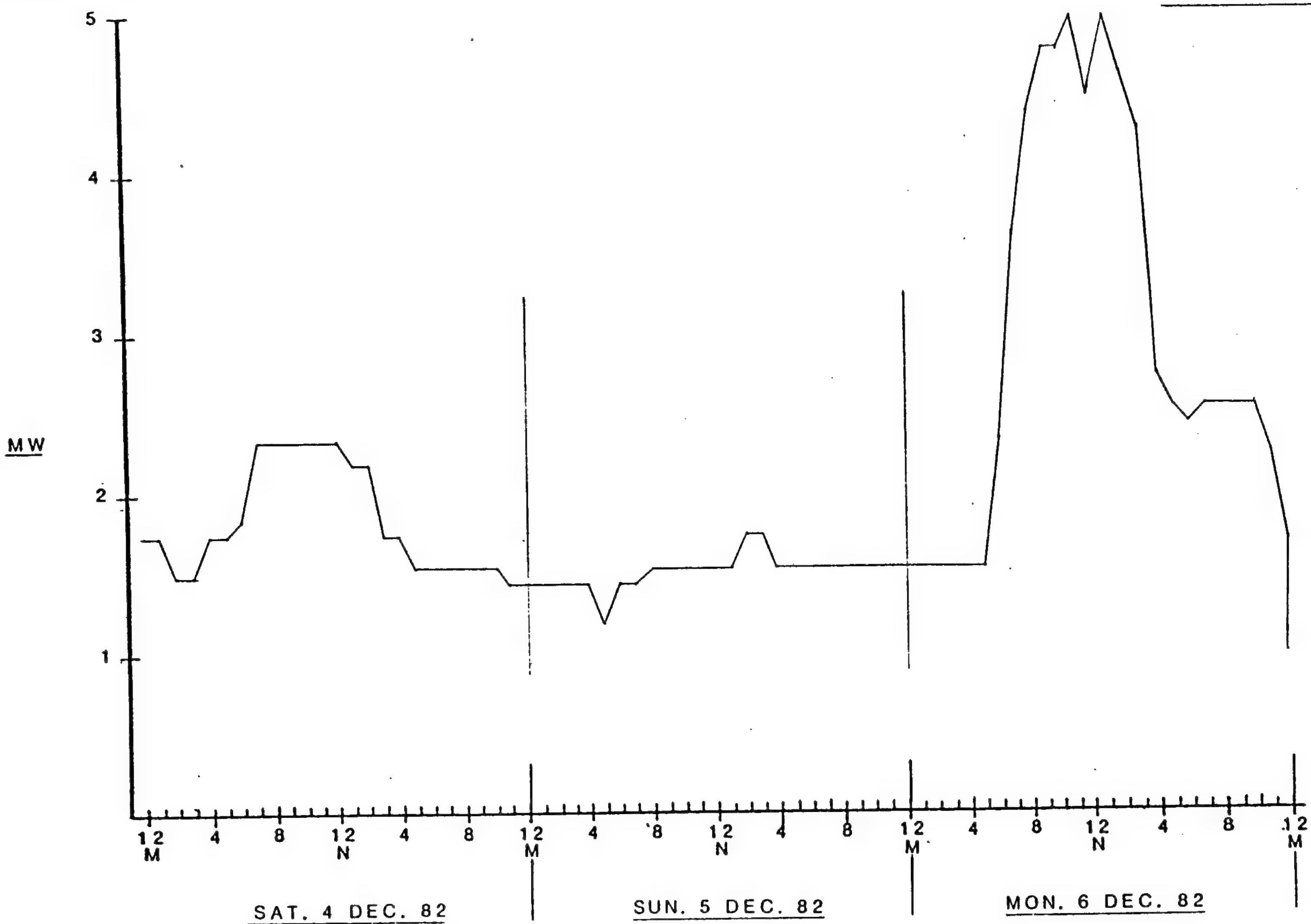
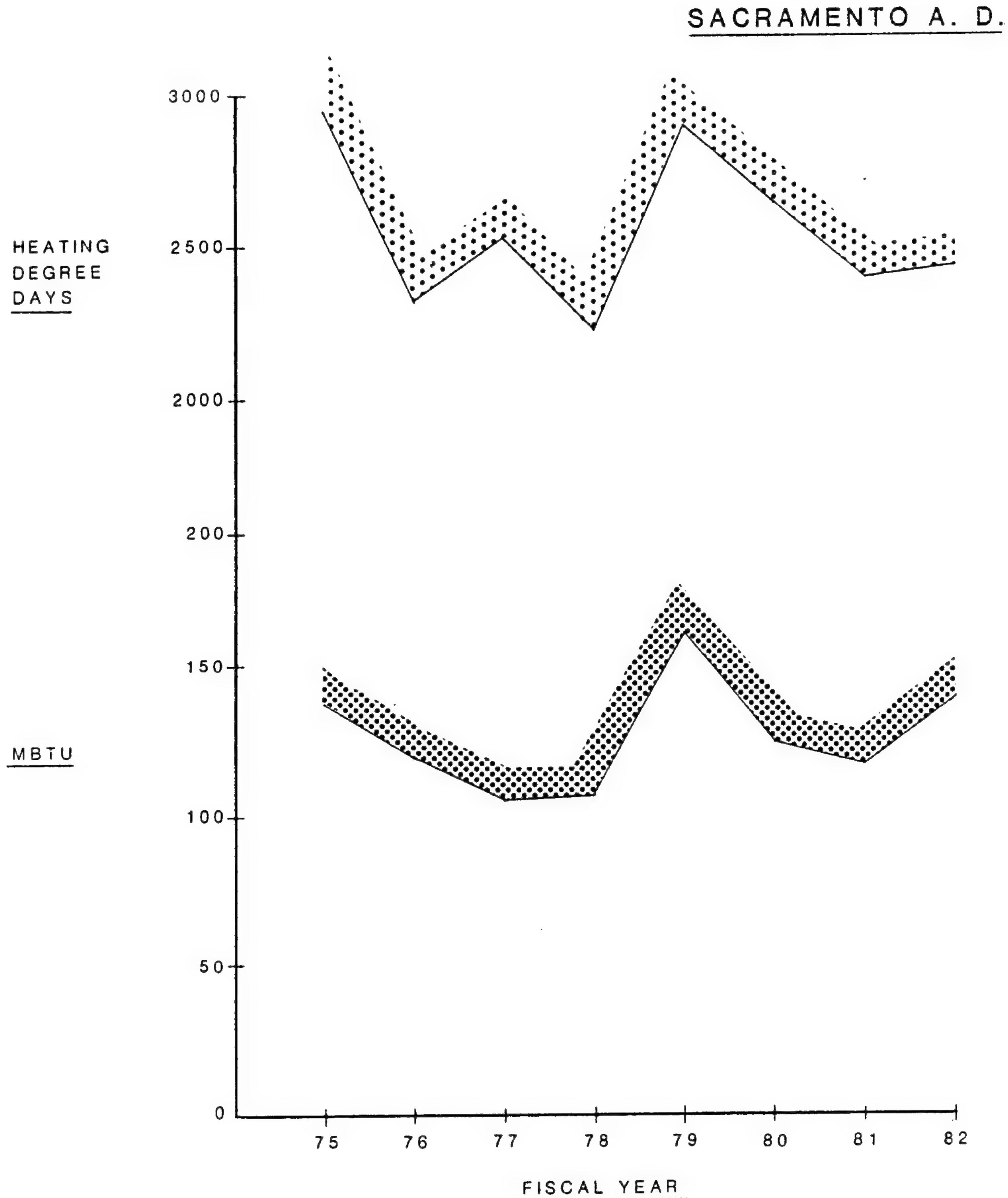


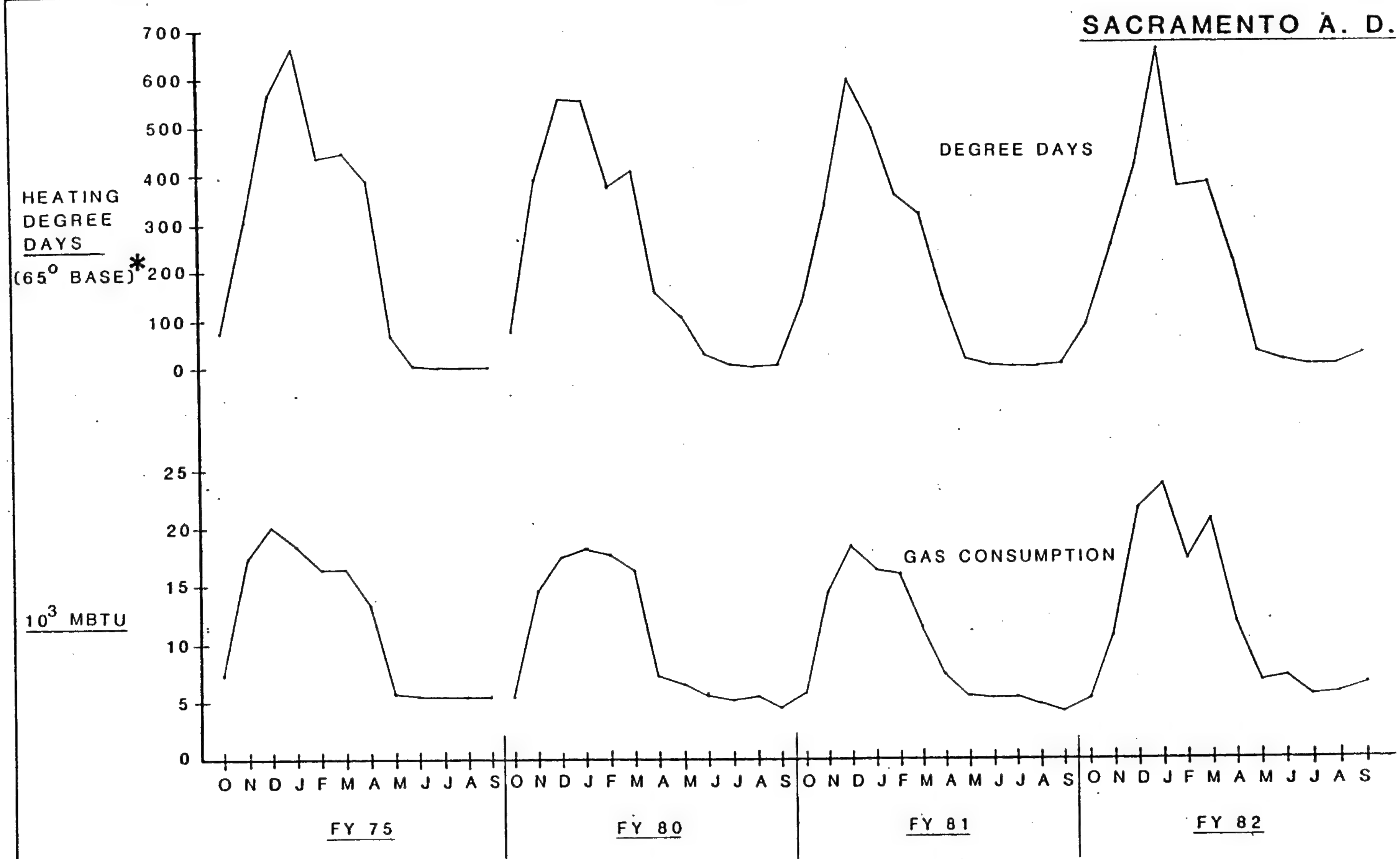
ELECTRICAL DEMAND PROFILE FOR WINTER WEEKEND

Fig. 2-6



ANNUAL DEGREE DAYS vs. TOTAL GAS CONSUMPTION FY 75-82

Fig. 2-7



MONTHLY DEGREE DAYS vs. GAS CONSUMPTION, FY 80, 81, & 82 vs. FY 75

Fig. 2-8

* Source: McClellan AFB, Sacramento

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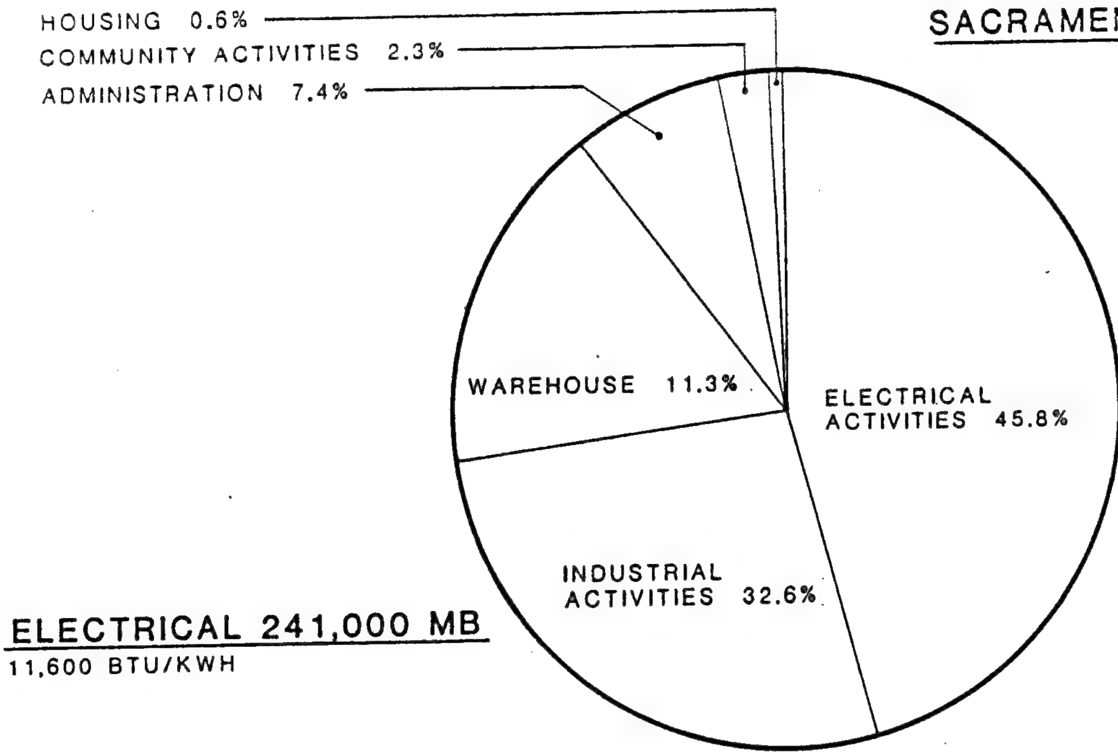
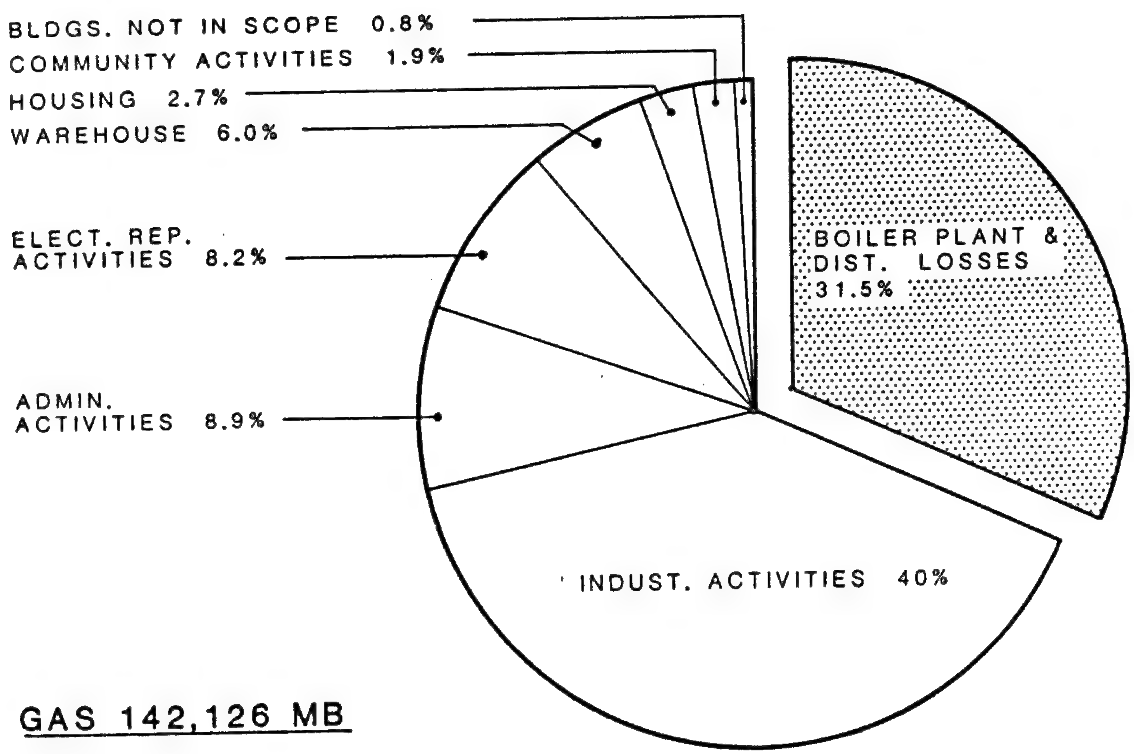




ENERGY CONSUMPTION BY BUILDING TYPE, FY 82

Fig. 2-9

Reference

are listed on the front page of each building description contained in Volume 4, Building Data Sheets.

2.6.2 Energy Consumption By System Type

Figure 2-10 indicates the total energy consumed by each general type of system at SAAD. Electrical consumption is split very evenly between process, lighting and HVAC. The boiler plant and distribution losses are very significant. HVAC includes all fans, pumps, chillers, evaporative coolers used to heat and cool the buildings. Process includes all forms of industrial, commercial and residential processes such as air compressors, typewriters and appliances respectively. Lists of equipment and lighting in each building are included in the building descriptions contained in the Building Data Sheets volume. Vol. 1 Sec. 3.6.2

2.7 ENERGY PROJECTS COMPLETED

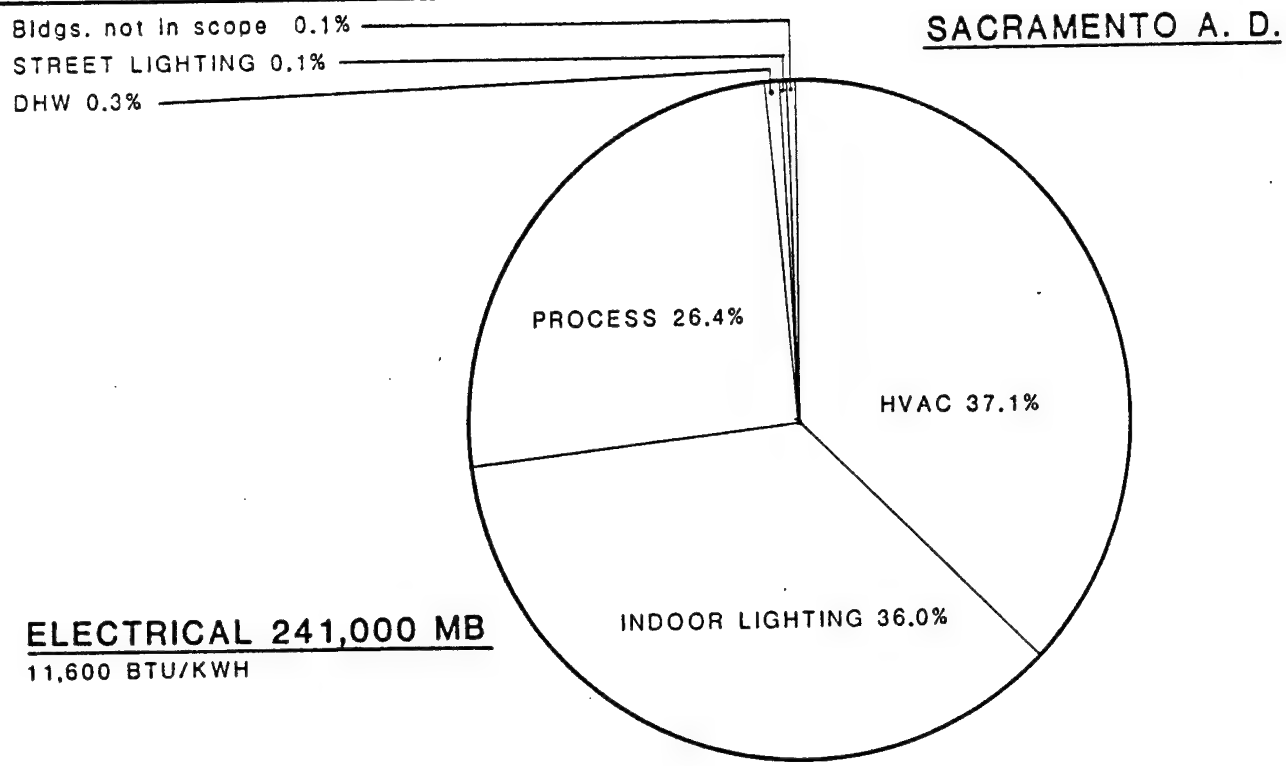
SAAD has completed the following conservation measures as of 1 December, 1982. Vol. 1 Sec. 3.7.1

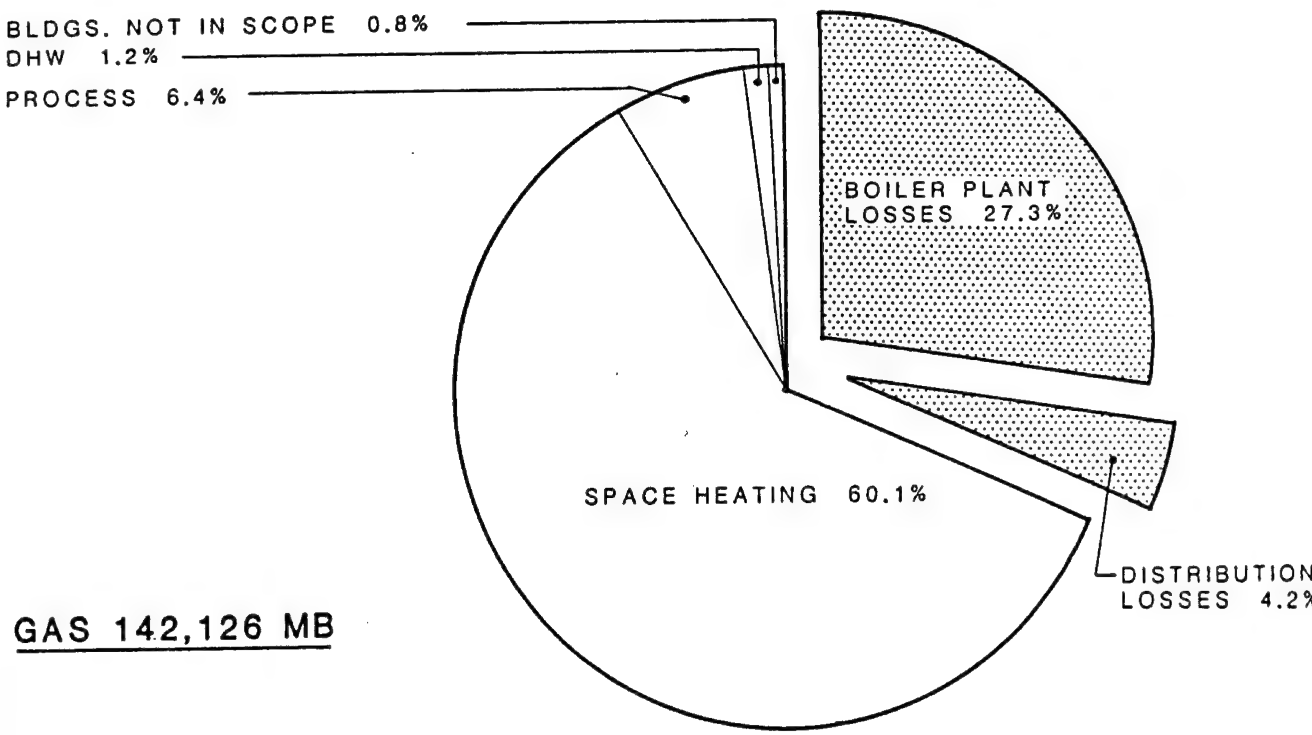
TABLE 2.5

ENERGY PROJECTS COMPLETED AS OF DEC '82

1. Install electrical meters on high demand bldgs.
2. Install timeclocks on larger HVAC systems.
3. Lean-To covers over outside refrig. and ice machines.
4. Replace energy intensive production equipment, i.e. packaging conveyor.
5. Energy Awareness Program, i.e. public display of energy consumption charts, "turn-off lights", posters, etc.
6. Delamp various buildings.
7. Promote carpooling.
8. Infra-red survey of steam traps.
9. Infra-red survey of high voltage connections.
10. Zone control of HVAC in Bldg. 650.
11. Replace gas vehicles with electric vehicles.
12. Caulk Bldg. 150 windows.

13. Turn off swimming pool heaters.
14. Replace/repair part of steam distribution system.
15. Reduce guard patrols.
16. Reconnect Bldg. 382 to central steam.





ENERGY CONSUMPTION BY SYSTEM TYPE, FY 82

Fig. 2-10

CHAPTER 3

ENERGY CONSERVATION MEASURES & ADJUSTED LOAD PROFILES

Reference

3.1 GENERAL DISCUSSION

62 buildings were included in Increments A, B, and G. Thier analysis was conducted in the following general manner: Vol. 1 Sec. 4.1

1. Audit buildings for general description of building construction, schedules, and equipment.

2. Compile Building Data Sheets summarizing initial audit information (Volume 4).

3. Review Building Data Sheets to identify potential Energy Conservation Measures (ECM) and systems requiring additional inspection.

4. Reinspect buildings and systems requiring additional information.

5. Conduct system tests and recordings.

6. Writeup projects using either hand or computer calculations as appropriate.

A complete detailed explanation of the analysis procedure can be found in sections 4.2 and 4.3 of Volume 1.

3.2 ENERGY CONSERVATION MEASURES RECOMMENDED

3.2.1 Increments A & B

Energy Conservation Measures involving buildings and utility systems whose project cost exceeds $200,000 and whose Savings to Investment Ratio (SIR) are greater than 1.0 are recommended for Energy Conservation Investment Program (ECIP) funding. Vol. 1 Sec. 4.4.1

Table 3.1 lists Increment A and B project recommendations. The projects are prioritized by

Reference

SIR and indicate the project cost, annual energy and cost savings, payback and SIR. Table 3.2 summarizes the impact of Increment A and B projects on the total energy consumption.

3.2.2 Increment F

Increment F includes O&M Projects and Increment A and B projects which meet all the ECIP criteria except project cost ($200,000). Vol. 3 Sec. 4

Table 3.3 lists Increment F projects and is organized in the same manner as Table 3.1. Table 3.4 summarizes the impact of Increment F projects on the total energy consumption.

3.2.3 Increment G

Increment G includes projects considered for Increments A and B but which do not meet ECIP criteria. Vol. 1 Sec. 5.1

Table 3.5 lists the Increment G project.

TABLE 3.1

SUMMARY OF INCREMENT A & B PROJECTS

Description	Project Cost ($)	Annual Savings Energy	Annual Savings $	SIR
ECIP Project to Install EMCS (FM Transmission)	232,364	18,276 MB 344,402 KWH	110,354	7.7
ECIP Project to Replace Central Plant Boiler	748,659	10,830 MB	58,791	1.3
	981,023	29,106 MB 344,402 KWH	169,145	

TABLE 3.2

INCREMENT A & B IMPACT ON TOTAL ENERGY

	Electricity MB/Yr(1)	Fuel (MB/yr)	Total Energy MB/Yr)
FY 75	248,217	140,466	388,683
Incr. A & B Reduction	3,995	29,106	33,101
% Reduction	1.6	20.7	8.5

(1) Per DEIS II report electricity conversion 0.0116 MB/KWH

TABLE 3.3

SUMMARY OF INCREMENT F PROJECTS

Description	Project Cost ($)	Annual Savings Energy	Annual Savings $	SIR
Reduce Steam Pressure Bldg. 352	237	365 MB	1792	24888
Reduce Run Time of Shrink Machine - Bldg. 242	0	220 MB 4334 KWH	1431	18000
Reduce Exhaust/OSA Ventilation - Bldg. 150	188	727 MB -1034 KWH	3966	281
Revise T-Stat Settings Various Bldgs.	5630	31,814 MB 405,517 KWH	183,000	195
Plastic Discs on Dip Tanks - Bldg. 420	715	1590 MB	8838	166
Close OSA Dampers at Night - Bldg. 150	120	202 MB 3133 KWH	1103	112
Insulate Piping & Equipment Various Bldgs.	1201	936 MB 476 KWH	4902	52
Reduce Excess Air/Boiler Tuneup - Bldg. 352	9900	4475 MB	24,801	31
Replace Condensate Equipment Bldg. 352	8792	2890 MB -13,034 KWH	15,028	23
Reduce Eqpt. Run Time - BOQ HV Unit - Bldg. 140	263	67 MB 858 KWH	393	18
Repair Economizer Bldg. 245	1018	102,850 KWH	1551	16
Lower D.H.W. Temperature Various Bldgs.	714	157 MB 2196 KWH	919	16
Reduce Eqpt. Size - Boiler Bldg. 245	4899	1079 MB -3448 KWH	6286	16
Night Setback & Zone Control - Bldg. 150	10363	2387 MB 8393 KWH	12,610	15
Timeclock/Night Setback Bldg. 555	7933	1055 MB 178,762 KWH	8561	12.7
Reduce Reheat - Bldg. 555	12,916	1920 MB 29,625 KWH	11,490	10.7
D.H.W. Recirculation Pump Control - Various Bldgs.	58	3530 KWH	53	9.9

TABLE 3.3 (Cont'd)

SUMMARY OF INCREMENT F PROJECTS

Description	Project Cost ($)	Annual Savings Energy	$	SIR
Timeclock/Night Setback Various Bldgs.	119,416	16,806 MB 23,966 KWH	93,376	9.6
Shut Down Summer Steam	17,618	2256 MB	11,799	8.2
Economizer/Reduce OSA Bldg. 300	9,318	965 MB 15,379 KWH	5,598	7.3
Boiler Stack Economizer Bldg. 352	81,619	8711 MB	47,573	7.2
Timeclock/Night Setback Bldg. 300	1652	118 MB 5015 KWH	731	5.4
Delamp - Various Bldgs.	6866	-1708 MB 853,566 KWH	23,421	4.3
Infrared Heating Bldgs. 330 & 439	10,450	480 MB	2,806	3.6
Timeclock Control of Lights Bldg. 150	8141	131,622 KWH	2,807	3.6
Insulate Walls Various Bldgs.	60,973	2,873 MB	15,976	3.2
Reduce Reheat/Convert DX to CHW System - Bldg. 300	21,546	912 MB 21,954 KWH	5,402	3.0
Reduce Eqpt. Run Time - Add Louvers - Bldg. 245	30,162	373,142 KWH	7,356	2.5
Economizers - Bldg. 245	43,946	654,667 KWH	9,872	2.4
DHW Tank Insulation Various Bldgs.	2,943	86 MB 3,367 KWH	545	2.2
Add/Repair HVAC Economizers Various Bldgs.	665	12,496 KWH	125	2.2
D.H.W. Flow Restrictors Various Bldgs.	9661	560 MB 4,897 KWH	1,000	1.9
Insulate Roofs Various Bldgs.	2800	77 MB 2 KWH	427	1.9
Convert to Cooling Tower Bldg. 245	27,434	244,767 KWH	4,881	1.8

TABLE 3.3 (Cont'd)

SUMMARY OF INCREMENT F PROJECTS

Description	Project Cost ($)	Annual Savings Energy	$	SIR
Replace Lighting Fixtures Various Bldgs.	26,335	-33 MB 229,623 KWH	9,217	1.8
Insulate Dip Tanks Bldg. 420	29,641	612 MB	3,404	1.4
Replace Lamps Various Bldgs.	215	-1 MB 1630 KWH	46	1.3
Photocell Control of Lights Various Bldgs.	73,399	-148 MB 516,947 KWH	26,923	1.3
Reduce HW Circ. Pump Operation - Bldg. 680	80	440 KWH	9	1.2
Weatherstripping Various Bldgs.	85,109	1485 MB -8076 KWH	8,132	1.2
Plastic Door Curtains Various Bldgs.	44,363	749 MB	4,163	1.2
Manual Timer on Lights Various Bldgs.	1,088	-16 MB 12,372 KWH	677	1.1
Total for Projects w/SIR > 1	$780,387	84668 MB 3,819,934 KWH	$572,990	
Economizers - Bldg. 555	10,702	45309 KWH	1,284	.9
Reduce Eqpt. Run Time (CHW Pumping System) - Bldg. 245	8,267	37293 KWH	710	.9
Chilled Water Reset Bldg. 150	2,285	11266 KWH	170	.8
Pre-cool Cycle Bldg. 150	551	2042 KWH	31	.6
Double Glaze Windows Various Bldgs.	3,726	32 MB	178	.6
Non-Solar Glass Bldgs. 439 & 680	3,868	14 MB 440 KWH	83	.3
Reduce Eqpt. Run Time (Shut off pilots & refrigs.) Bldg. 180	977	34 MB 8925 KWH	-603	-5218
Total for Projects w/SIR < 1	30,376	80 MB 105,275 KWH	1853	

TABLE 3.4

INCREMENT F IMPACT ON TOTAL ENERGY

	Electricity MB/Yr(1)	Fuel MB/Yr	Total Energy MB/Yr
FY 75	240,900	141,730	382,630
Incr. F Reduction	44,311	84,668	128,979
% Reduction	18.4	58.7	33.7

(1) 11,600 Btu/KWH

TABLE 3.5

INCREMENT G PROJECT

Description	Project Cost	Annual Savings Energy	Annual Savings $	Payback	SIR
ECIP Project to Install Gas Turbine Cogeneration	$1,410,000	(2)	281,479	5.0	-2.35

(2) Project reduces utility company energy consumpion not SAAD's. SAAD realizes cost savings.

Reference

3.3 OTHER RECOMMENDATIONS

3.3.1 Training

Table 3.6 lists some recommended training classes offered by the U.S. Army and 3 private companies. These classes were selected for their particular applicability to SAAD. Listed is the class, sponsor, cost, schedule (if available) and location. Vol. 1 Sec. 2.1.2

3.3.2 Equipment Replacement

Table 3.7 lists various pieces of energy efficient equipment recommended for change-out replacements when old equipment is replaced. A complete description of each type of equipment can be found in Chapter 5 of Volume 3. Vol. 3 Sec. 5.1

3.3.3 Electrical Metering

Metering is an energy management tool to help the Facilities Engineer identify potential energy conservation measures that might otherwise be overlooked. Metering itself does not save energy. SAAD currently has 18 meters in use capable of accounting for 40% of the electrical usage. Figure 3-2, Volume 1 shows 9 recommended locations for new meters. Vol. 1 Sec. 3.8.2

3.3.4 Natural Gas Metering

There are currently 12 buildings on base that are metered. It is recommended that a gas meter be installed in Bldg. 555 due to the large amount of gas that the building consumes. Vol. 1 Sec. 3.8.3 Sec. 3.8.4

TABLE 3.6

RECOMMENDED TRAINING FOR F.E.

Course	By	Cost($)	Schedule	Location
Building Loads Analysis & System Thermodynamics (BLAST)	Corps of Engineers	850	3/19-3/24/84	Washington, D.C.
Computer Aided Design for Buildings	"	1265	1/23-1/27/84	Vicksburg, Miss.
Economic Study: Milcon Design Application	"	670	3/19-3/23/84	Huntsville, Ala.
Energy Conservation for New Buildings	"	580	6/20-6/24/83	"
Energy Conservation in Existing Buildings	"	470	1/16-1/20/84	"
Energy Monitoring & Control Systems (EMCS)	"	585	2/6 -2/10/84	Washington, D.C.
	"	"	6/4 - 6/8/84	Huntsville, Ala.
	"	"	7/23-7/27/84	San Antonio, Tex.
Mechanical Inspection	"	400	11/15-11/19/83	Atlanta, Georgia
	"	345	12/12-12/16/83	Kansas City, Mo.
	"	345	4/9 - 4/13/84	Atlanta, Georgia
Refrigeration & Air Conditioning Inspection	"	495	1/23- 1/27/84	Kansas City, Mo.
Solar Active Energy	"	660	6/20- 6/24/83	Huntsville, Ala.
System Design	"	560	6/18- 6/22/84	"
Solar Passive Energy	"	660	6/13- 6/17/83	"
Design For Buildings	"	615	6/25- 6/29/83	"
Building Manager	Johnson Controls Incorporated	425-660		Milwaukee, Wis.
Air Conditioning Fund	"	"		"
Maintenance Supervision	"	"		"
Air Conditioning Controls	"	"		"
HVAC Energy Management	"	635		"
Reciprocating Eqpt. Operation & Maint. Seminar	Trane Company	150-200		Sacramento, Cal.

TABLE 3.6 (Cont'd)

RECOMMENDED TRAINING FOR F.E.

Course	By	Cost($)	Schedule	Location
Commercial Unitary Eqpt. Service Seminar	Trane Company	300		Sacramento, Cal.
Boiler Efficiency Seminar	Boiler Efficiency Institute P.O. Box 2255 Auburn, Ala.	200	2 days	Various Loc'ns across U.S.

TABLE 3.7

REPLACEMENT EQUIPMENT

Stack Economizer

Caulking

Weatherstripping

Plastic Curtains

Thermostats

T-Stat Limiters

Rooftop & Window HVAC Units

Timeclocks

Insulation

Exhaust Heat Reclaim Units

Intermittent Ignition Devices

Extra DHW Tank Insulation

Smaller DHW Tanks

Low Temperature Dishwashers

Flow Restrictors

Low Wattage/High Efficiency Lighting

High Efficiency Electric Motor

Variable Speed Motor Controls

Reference

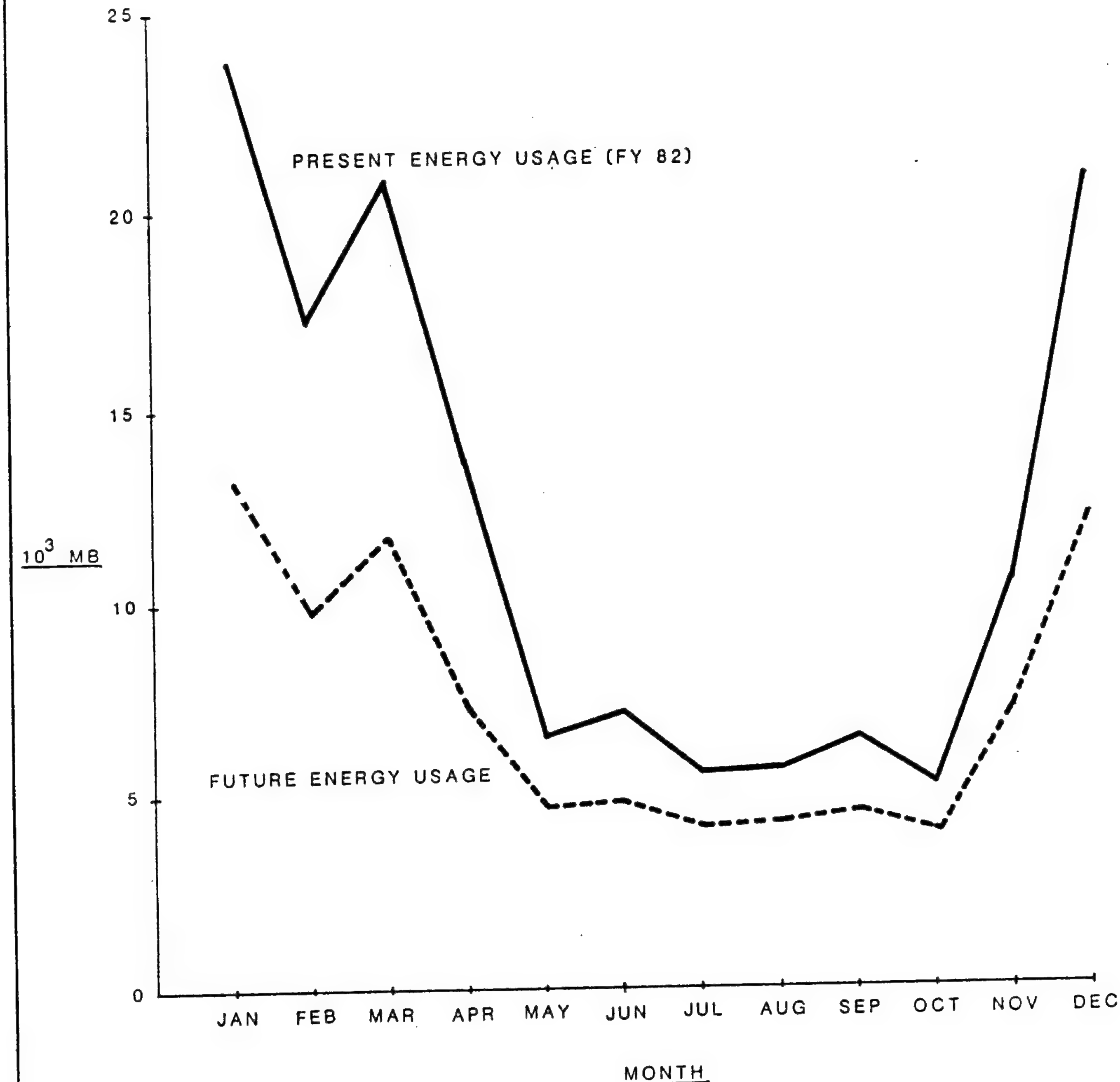
3.4 ADJUSTED ENERGY PROFILES

Adjusted thermal and electric load profiles were generated from existing load profiles with adjustments made for recommended energy conservation measures (TABLES 3.1 and 3.3). These adjusted profiles were used in the Increments C, D, and E (Chapters 5,6, and 7 analyses. Vol. 1 Sec. 4.5

Figure 3-1 indicates both the present and projected monthly fuel consumption for the Post, while Fig. 3-2 indicates the present and projected monthly electrical consumption and demand for SAAD.

Figures 3-3 and 3-4 indicate the projected average hourly weekday and weekend load profiles. These were used primarily in the cogeneration and boiler plant analyses, Chapter 6 and 7 (Incr. D and E).

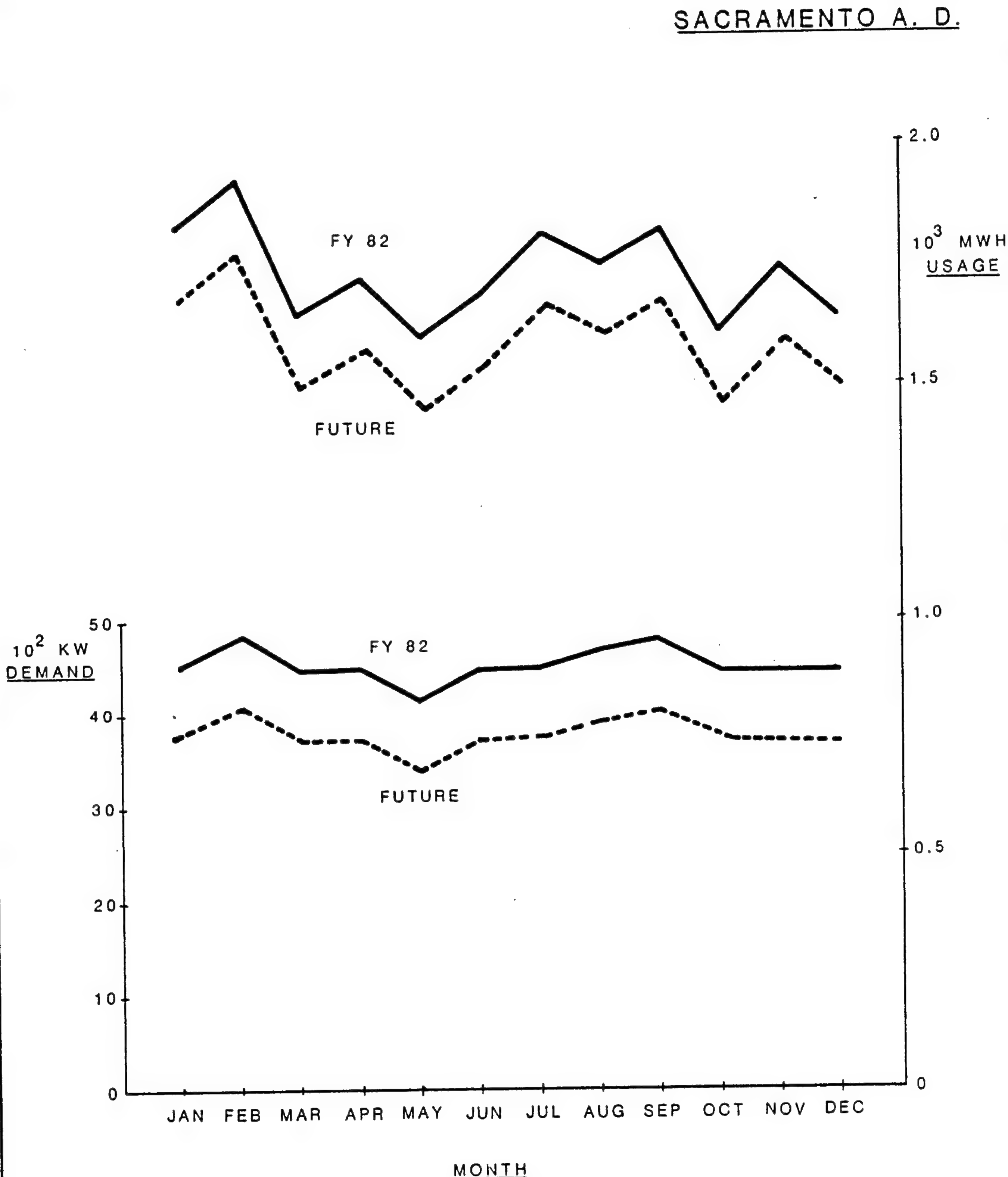
Figure 3-5 indicates the projected hours per year that thermal and electric demands occur. This data was used for computer modelling in the cogeneration analysis (Incr. D).



MONTHLY THERMAL PROFILE, FY 82 vs FUTURE*

* Assuming 59% reduction due to ECM's and central distribution system installed

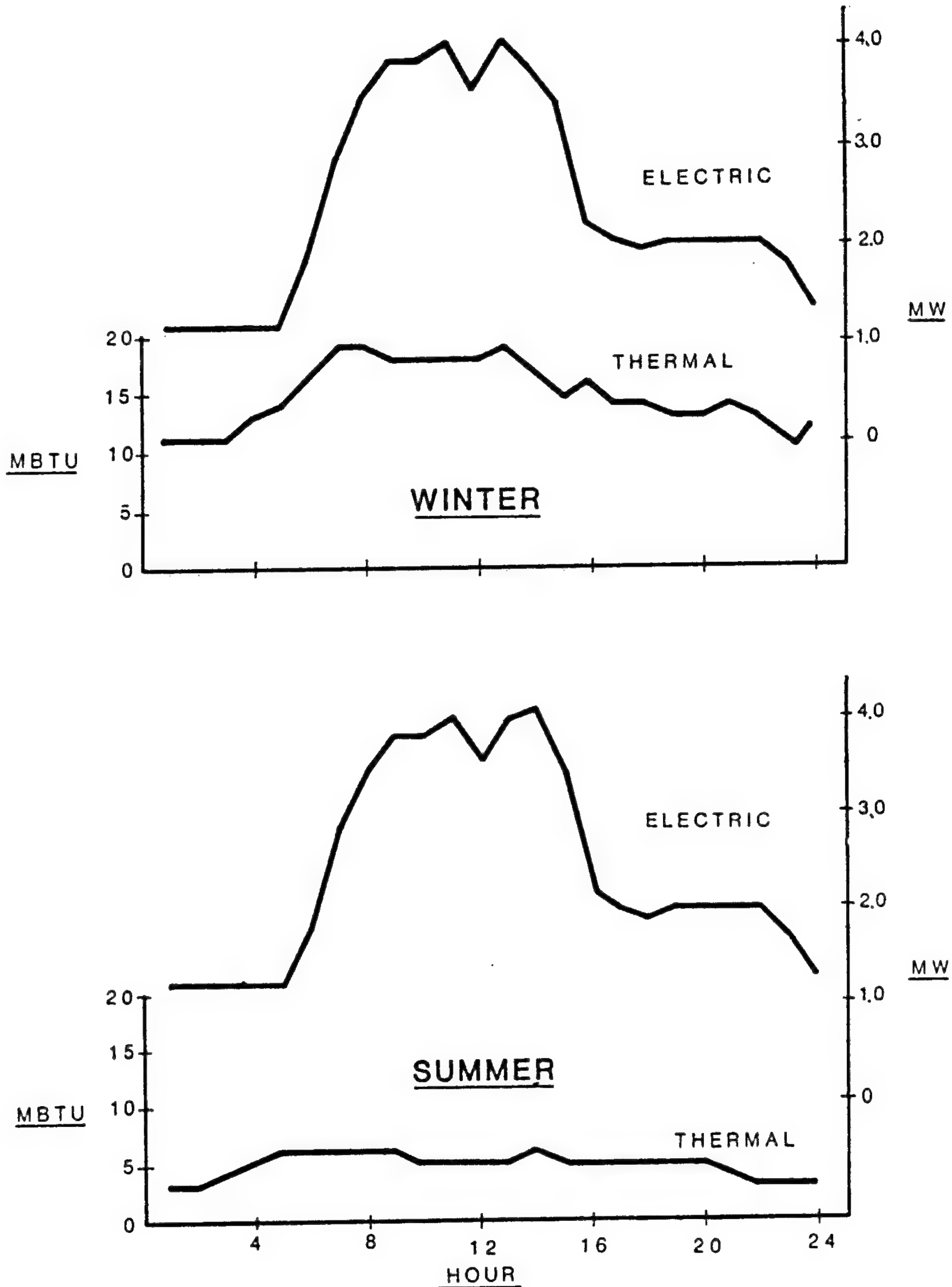
Fig. 3-1



MONTHLY ELECTRICAL PROFILE, FY 82 vs FUTURE*

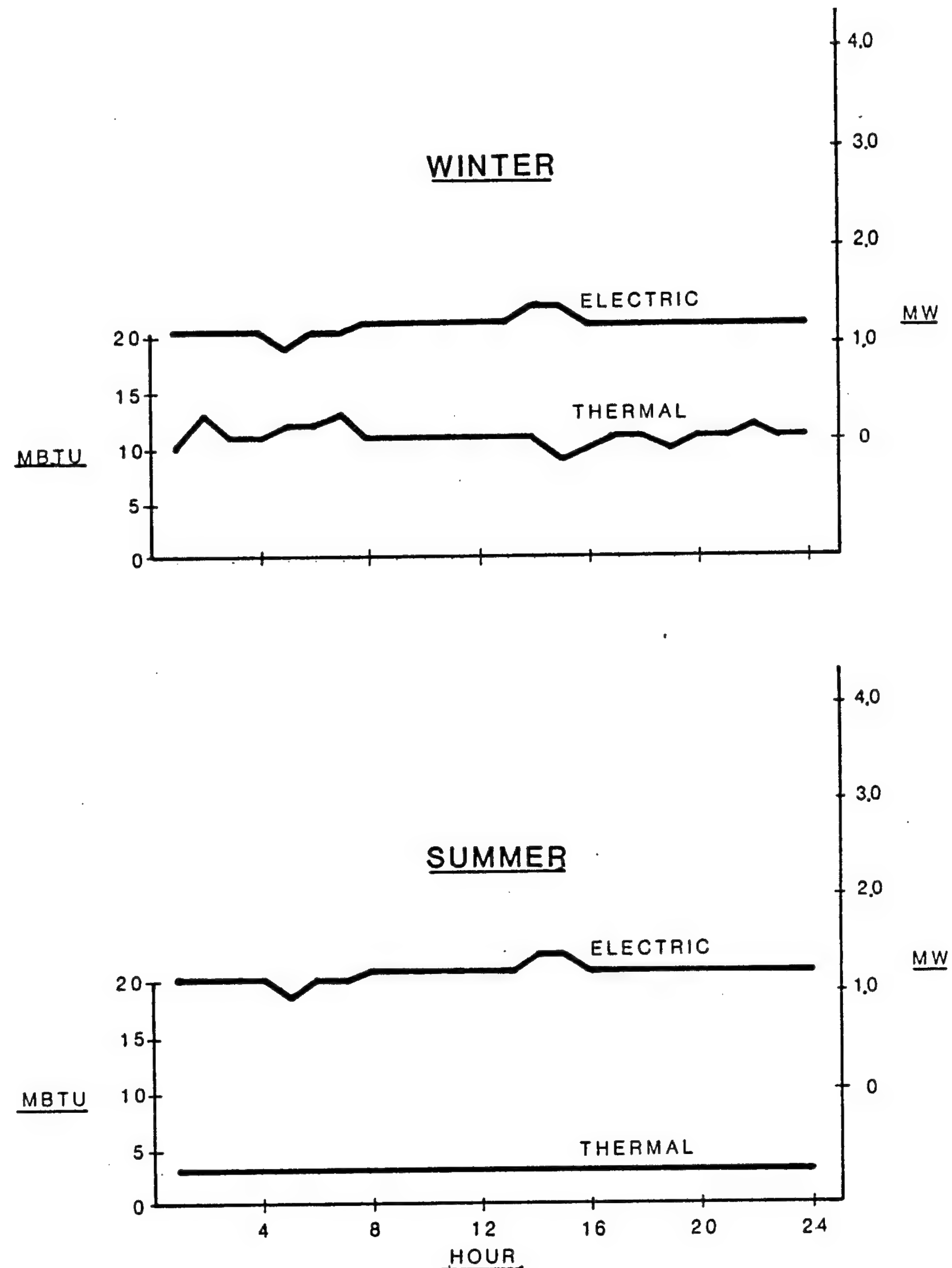
Fig. 3-2

*Assuming 15% reduction due to ECM's



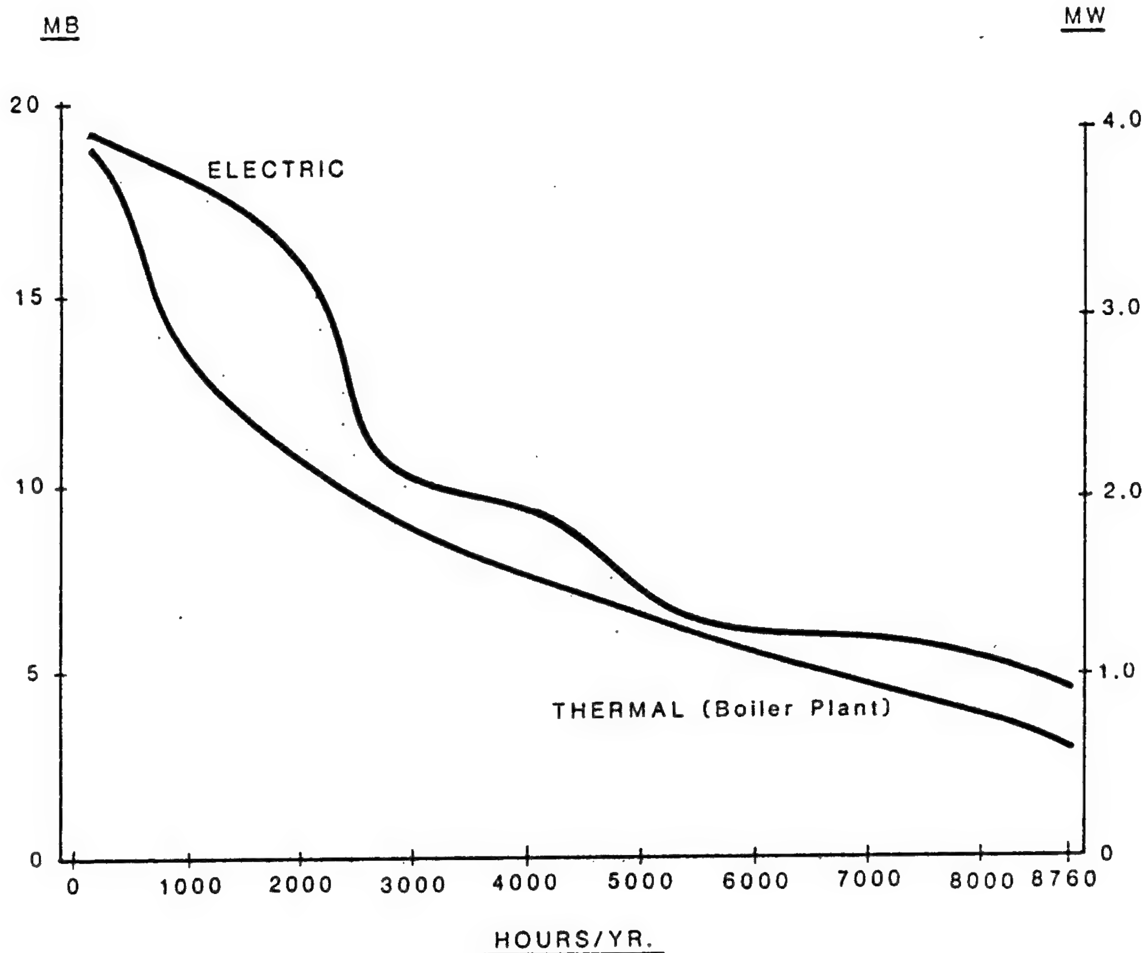
FUTURE THERMAL / ELECTRIC PROFILES FOR WEEKDAY

Fig. 3-3



FUTURE THERMAL / ELECTRIC PROFILES FOR WEEKEND

Fig. 3-4



ANNUAL OCCURRENCE OF THERMAL & ELECTRIC LOADS, FUTURE

Fig. 3-5

CHAPTER 4

ENERGY MONITORING & CONTROL SYSTEM (EMCS)

Reference

4.1 GENERAL

The analysis of an Energy Monitoring and Control System (EMCS) for SAAD was conducted using the following procedure: Vol. 1 Sec. 5.2

1. Field Data: Gather field data.

2. Screen Systems: Identify buildings/systems with potential energy savings through the use of an EMCS.

3. Select EMCS Programs: Select applicable EMCS energy conservation features to be considered.

4. Field & Facility Costs: Estimate sensor/actuators and connection costs.

5. EMCS Costs vs. Conventional Controls: Compare sensor/actuator and facility connection costs with the cost of conventional controls, by EMCS feature, and eliminate those features that can be accomplished with conventional controls at less cost.

6. Identify Points: Determine approximate number and type of points, by building.

7. Energy Savings: Quantify potential energy savings by building or system type.

8. Preliminary Economic Analysis: Conduct a preliminary economic analysis considering items 4 and 7 by building or system type.

9. Eliminate Uneconomical Systems: Temporarily disregard systems and permanently disregard entire buildings that are not individually economically justifiable.

Reference

10. Add Transmission & Central Computer Costs: Estimate cost of entire EMCS considering sensor/actuator and facility costs only for those buildings being justified in item 8.

11. Conduct Economic Analysis: Prorate cost of transmission and CCU on to cost of each point which passed preliminary screening.

12. Add Marginally Feasible Systems: If EMCS is economically feasible, add those systems temporarily disregarded in 9 in descending order of economic attractiveness without sacrificing the feasibility of the entire EMCS.

13. Final Economic Analysis: Conduct final economic analysis of entire EMCS.

14. Alternate Solutions For Uneconomical Systems: Consider alternative means of control for buildings that cannot be economically connected to an EMCS.

4.2 ANALYSIS OF HARD-WIRE SYSTEM

4.2.1 Field Data

The field data used to determine the feasibility of an EMCS is generally the same data used in the evaluation of the conventional energy conservation options covered in Increments A, B, F and G. Vol. 1 Sec. 5.3.1

Additionally, information concerning the existing data transmission media (DTM) was obtained for the EMCS feasibility evaluation.

The depot telephone system is capable of handling data transmissions of 1200 bps and an electronic data processing (EDP) system is currently in use as evidence of this capability.

4.2.2 Screen Systems

Generally, the existing mechanical systems were found to be small, unsophisticated, and possibly not ideal for an EMCS. Systems with satisfactory Vol. 1 Sec. 5.3.2

Reference

existing conventional controls were not considered for inclusion in the EMCS.

4.2.3 EMCS Programs

The following EMCS software functions were considered: Vol. 1 Sec. 5.3.3

- Scheduled Start/Stop
- Optimum Start/Stop
- Duty Cycling
- Demand Limiting
- Occupied/Unoccupied
- Day/Night Setback
- Economizer
- Chilled Water Reset
- Condenser Water Reset
- Chiller Demand Limit
- Lighting Control

4.2.4 Field & Facility Costs

The preliminary analysis used the following material and labor costs: Vol. 1 Sec. 5.3.4

TABLE 4.1

HARD WIRE EMCS COSTS

Facility Connection Costs	Mat'l	Labor	Total
FID w/power supply	$2,400	$585	$2,985
Modem	$ 425	$ 78	$ 503
MUX	$ 920	$ 78	$ 998
			$4,486
Point Costs			
Temp./Humidity	$ 110/440 (1)		
Start/Stop	$ 61/244 (2)		
Status	$ 33/264 (3)		
Control Point Adjust.	$ 186/745		
Sensor/Actuator Costs (4)			
Temp./Humidity	$ 70	$111	$ 181
Start/Stop	$ 76	$111	$ 187
Status	$ 90	$131	$ 221
Control Point Adjust.	$ 196	$ 91	$ 287
Sensor Connection Costs			
Conduit, ½" EMT w/2 #18	$.80/LF	$1.44	$2.24

Notes:

(1) $110/pt or $440 for card w/4 pt. capacity
(2) $61/pt or $244 for card w/4 pt. capacity
(3) $33/pt or $264 for card w/8 pt. capacity
(4) Cost includes field instrument and 50 LF of conduit and wire

Reference

4.2.5 Conclusion Regarding Hard-Wire System

A cost comparison between EMCS and conventional controls was made for each of the functions listed in paragraph 4.2.3 as well as multiple functions on a single system. The comparisons indicated that in, all cases except demand limiting, hard-wire EMCS control was more costly than conventional control. Therefore, it was concluded that a hard-wire EMCS is not economically feasible at SAAD. Vol. 1 Sec. 5.3.5

4.3 ALTERNATE SYSTEMS

The alternate methods of control considered were FM radio control, both with two-way and one-way communications, and current carrier control. An FM based, one-way communications EMCS was selected for further consideration for the following reasons: Vol. 1 Sec. 5.4

1. The cost of the two-way FM control systems approach the cost of hard-wire systems, which were shown not to be economically feasible.

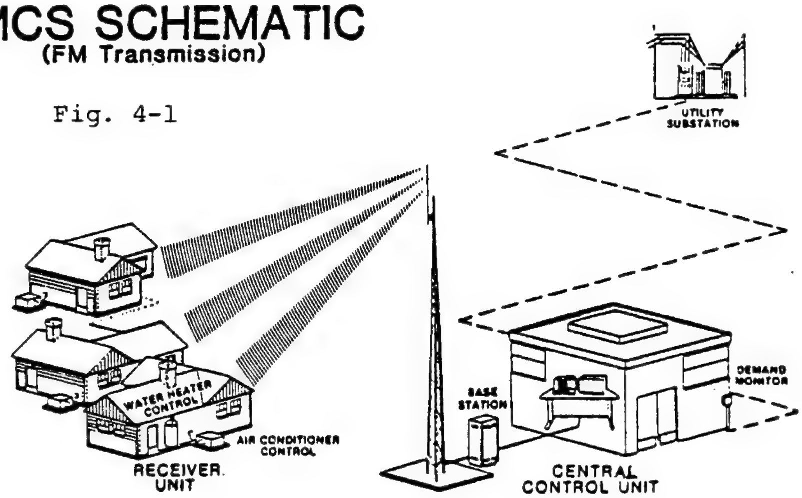
2. The decentralized nature of the mechanical equipment at SAAD does not favor a current carrier system which would require numerous network couplers and amplifiers.

3. The functions required by SAAD are typically those functions most easily provided by an FM based, one way EMCS.

An FM based EMCS, as considered, consists of receiver units, base station with antenna and Central Control Unit (CCU), and is depicted in Fig. 4-1.

EMCS SCHEMATIC
(FM Transmission)

Fig. 4-1



Reference

4.4 ANALYSIS OF 1-WAY FM BASED EMCS

4.4.1 Procedure

Because of the differences between a hard-wire and FM based EMCS, the procedures described in paragraph 4.1 were modified to: Vol. 1 Sec. 5.5.1

1. Field Data: Gather field data.

2. Screen Systems: Identify equipment within each building/system with potential energy savings through the use of an EMCS.

3. Select EMCS Programs: Select applicable EMCS energy conservation features to be considered.

4. Identify EMCS Field Equipment: Determine approximate number of receivers corresponding to number of pieces of equipment identified in item 2.

5. Field vs. Conventional Controls: Estimate receiver, other field equipment and Central Control Unit/Base Station installation costs.

6. EMCS vs. Conventional Controls: Compare the costs from item 5 with the cost of conventional controls for each EMCS feature identified in item 3, and eliminate those features that can be accomplished with conventional controls at less cost.

7. Savings: Quantify potential energy savings and non-energy savings for each piece of equipment identified in item 2.

8. Preliminary Economic Analysis: Conduct a preliminary economic analysis considering the cost established in item 5 vs. the savings calculated in item 7. Eliminate pieces of equipment whose inclusion in the EMCS is not economically justified.

9. Final Economic Analysis: The final economic analysis is conducted when, through iterations of item 8, all equipment considered produces SIR's > 1 or no equipment

Reference

remains to be considered, in which case the EMCS project would be considered not economically feasible.

The collection of field data and identification of potential energy savings as described in para. 4.2.1 and 4.2.2 also pertain to an FM based EMCS.

4.4.2 EMCS Programs

The EMCS software functions considered are those listed in paragraph 4.2 3 except for the following functions which require feedback from the devices to the CCU. Vol. 1 Sec. 5.5.2

- Optimum Start/Stop
- Economizer
- Chilled Water Reset
- Condenser Water Reset
- Chiller Demand Limit

4.4.3 Field Equipment & CCU/BS Costs

After screening all building/systems contained in the scope of work, 416 pieces of equipment were identified for control by the EMCS. Vol. 1 Sec. 5.5.3 Sec. 5.5.4

The installation costs, for the purposes of preliminary analysis are as follows:

TABLE 4.2

FM BASED EMCS COSTS

CCU/BS Costs	Mat'l	Labor	Total
CCU	$24,000	$3,409(175 MH)	$27,409
CCU/Demand Limiting Package	$ 1,200	$ 234(12 MH)	$ 1,434
Base Station	$ 6,000	$2,240(115 MH)	$ 8,240
Training	-	$3,409(174 MH)	$ 3,409
			$40,492
Field Costs			
Receiver Unit	$ 106	$ 19	$ 125
Sensor Costs			
Hi/Lo Limit	$ 31	$ 19	$ 50
Sensor Connection Costs			
Conduit, ½ EMT w/2 #12	$ .80/LF	$1.44/LF	$2.24/LF

Reference

4.4.4 FM Based EMCS vs. Conventional Controls

A cost comparison between EMCS and conventional controls was made, the results of which indicated the FM based EMCS as more economically attractive than conventional contros.

Vol. 1 Sec. 5.5.5

4.4.5 Economic Analysis

Table 4.3 indicates the results of the individual economic analyses performed on each piece of equipment considered for inclusion in the EMCS. Successive iterations are performed, eliminating equipment with unsatisfactory SIR's and dividing the Central Control Unit and Base Station costs amongst the remaining equipment. All equipment in the energy conservation project Night Setback/Timeclocks recommending conventional controls is included in each iteration, regardless of SIR, so that a proper comparison can be made between the two projects.

Vol. 1 Sec. 5.5.7

This analysis shows an EMCS containing 172 points produces an SIR of 8.28.

Abbreviations/Symbols used in Table 4.3:

P	Permanent Bldg.
T	Temporary Bldg.
DC	Duty Cycling
DL	Demand Limiting
D/N	Day/Night Setback
S S/S	Scheduled Start/Stop
*	Denotes bldgs. containing NAF activities
+	Denotes equipment recommended for inclusion in EMCS

4.4.6 Recommendations

We therefore conclude that an FM based EMCS is a viable energy conservation project and should be pursued through a request for ECIP funds. DD 1391's for this project are included in Chapter 1, Volume 2.

Vol. 1 Sec. 5.5.7

4.4.7 Input/Output Summary Tables

Building Summary Tables and I/O Summary Tables for the FM based EMCS are included with the

Vol. 1 Sec. 5.5.9

programming documents for this project, Chapter 1, Volume 2.

TABLE 4.3

EMCS ANALYSIS

Bldg No.	T or P	Equipment Controlled	EMCS Programs	Energy Savings Gas (MB/Yr)	Energy Savings Elect (KWH/Yr)	Equip Demand (KWH)	Demand Savings ($/Yr)(*1)	Receiver Units (ea.)	Hi/Lo T'Stat (ea.)	Add'n Equip (note *)	Field Costs ($)(*2)	Savings to Investment Ratio (SIR) Iteration (*3) #1	#2	#3	#4	#5
130	P	Evap clr	DC,DL		66.00	0.40	9.24	1	1		287.00	0.03				
		UH(elec)	DC,DL		224.00	1.50	27.45	1	1		287.00	0.09				
140*	T	Window AC (9)	DC,DL		1881.00	11.40	244.87	9	9		2583.00	0.09				
		+ HV Unit(Store Rm)	D/N,DC,DL	47.85	433.00	0.60	10.98	1	2	4	1210.00	1.89	1.72	1.71		
		+ HVAC(Utility Rm)	D/N,DC,DL		5557.00	12.80	267.31	1	2	4	1210.00	0.66	0.60	0.60		
		DHW(gas)	S S/S	0.60				1			125.00	0.13				
150	P	Chiller	DL			284.00	6100.32	1			125.00	0.00				
		+ AH(4)	DC,DL		15096.00	48.00	1987.20	4	4		1148.00	1.54	1.14	1.13		
		Pack AC(CO Off)	S S/S,DC,DL		236.00	9.20	197.62	1	1		287.00	0.10				
		Pack AC(Conf Rm)	S S/S,DC,DL		101.00	6.40	137.47	1	1		287.00	0.04				
		Exh Fan(2)	DC,DL		5032.00	16.00	662.40	2	2		574.00	1.02	0.76			
		+ Stm Htg	D/N	1060.05				1	1	4(2)	1810.00	27.30	25.52	25.45		
		+ Lights	S S/S		131622		821.88	7		5	5955.00	3.10	2.72	2.71		
152	P+	Elect Htg	DC,DL		3611.00	5.00	91.50	1	1		287.00	1.47	1.09	1.08		
		Window AC	DC,DL		91.00	2.10	45.11	1	1		287.00	0.04				
153	T+	Stm Htg	D/N	95.25				1	1	4	1048.00	4.09	3.66	3.65		
		Evap Clg	S S/S,DC,DL		702.00	0.60	13.86	1	1		287.00	0.29				
		Window AC	DC,DL		227.00	0.60	12.89	1	1		287.00	0.09				
154	T+	Stm Htg	D/N	104.25				1	1	4	1048.00	4.47	4.01	3.99		
		Chiller	DL			25.20	541.30	1			125.00	0.00				
		AH	DC,DL		396.00	2.40	55.44	1	1		287.00	0.16				
			Page Totals	1308.00	165275		11226.84	39	31		19544.00					

+ Equip recommended for EMCS

TABLE 4.3 (Cont'd)

Bldg No.	T or P	Equipment Controlled	EMCS Programs	Energy Savings Gas (MB/Yr)	Energy Savings Elect (KWH/Yr)	Equip Demand (KWH)	Demand Savings ($/Yr)(#1)	Receiver Units (ea.)	Hi/Lo T'Stat (ea.)	Add'n Equip (note #)	Field Costs ($)(#2)	Savings to Investment Ratio (SIR) Iteration (#3) #1	#2	#3	#4	#5
154	T	Window AC	DC,DL		15.00	0.75	16.11	1	1		287.00	0.01				
		DHW(gas)	S S/S	1.40				1			125.00	0.31				
180	P+	HVAC(south)	D/N,DC,DL	42.08	252.00	13.60	289.58	1	2		449.00	5.12	4.12	4.09		
	+	HVAC(north)	D/N,DC,DL	87.00	252.00	13.60	289.58	1	2		449.00	10.50	8.45	8.39		
		Chiller	DL			6.40	137.47	1			125.00	0.00				
		AH(first floor)	DC,DL		132.00	0.80	18.48	1	1		287.00	0.05				
	+	AH(second Floor)	D/N,DC,DL	92.33	264.00	0.80	18.48	1	2		449.00	8.59	6.90	6.85		
		DHW(gas)	S S/S	1.00				1			125.00	0.22				
181	P	HVAC(office)	DC,DL		831.00	5.60	105.98	1	2		449.00	0.24				
		UH (3)	DC,DL		120.00	0.80	14.64	3	3		861.00	0.02				
		Evap Clr (2)	DC,DL		13.00	0.80	18.48	2	2		574.00	0.00				
205	T+	UH (2)	D/N,DC,DL	20.93	1346.00	9.00	164.70	2	4		898.00	1.45	1.16	1.16		
		Evap Clr	DC,DL		66.00	0.40	9.24	1	1		287.00	0.03				
		DHW(elec)	S S/S,DL		48.00	4.50	55.89	1			125.00	0.03				
242	P	Fan Coil, Bay 1	S S/S,DC,DL		383.00	2.00	42.96	1	1		287.00	0.16				
		Pack Unit, CC off	DC,DL		3145.00	10.00	397.80	1	1		287.00	1.28	0.95			
		Evap Clr (6)	DC,DL		594.00	3.60	83.16	6	6		1722.00	0.04				
	+	UH & HV,Bay 4 (16)	D/N,DC,DL	846.53	3110.00	20.80	380.64	16	32	4	7945.00	4.68	3.83	3.80		
		AH, Bay 6	DC,DL		1887.00	6.00	248.40	1	1		287.00	0.77				
		Chiller	DL			13.60	292.13	1			125.00	0.00				
		Fan Coil,Bay 6 (2)	DC,DL		1650.00	10.00	214.80	2	2		574.00	0.34				
		DHW(elec)	S S/S,DL		176.00	8.00	99.36	2			250.00	0.06				
244	P	DHW(elec) (3)	S S/S,DL		181.00	12.50	155.25	3			375.00	0.04				
245	P	DHW(elec)	DL			4.50	55.89	1			125.00	0.00				
			Page Totals	1091.27	14465.00		3109.02	52	63		17467.00					

+ Equip recommended for EMCS

TABLE 4.3 (Cont'd)

Bldg No.	T or P	Equipment Controlled	EMCS Programs	Energy Savings Gas (MB/Yr)	Energy Savings Elect (KWH/Yr)	Equip Demand (KWH)	Demand Savings ($/Yr)(*1)	Receiver Units (ea.)	Hi/Lo T'Stat (ea.)	Add'n Equip (note *)	Field Costs ($)(*2)	SIR Iteration #1	#2	#3	#4	#5
246	P	Evap Clr	DC,DL		66.00	0.40	9.24	1	1		287.00	0.03				
		Htr (gas)	D/N	26.55				1	1		287.00	3.40	2.52	2.50		
		DHW(gas) (3)	S S/S	3.90				3			375.00	0.29				
248	P	HV & UH (42)	D/N,DC,DL	4736.33	13395.00	89.60	1639.68	42	84	4(6)	23424.00	8.91	7.41	7.36		
		Window AC (3)	DC,DL		297.00	1.80	38.66	3	3		861.00	0.04				
		UH(elec)	DC,DL		748.00	5.00	91.50	1	1		287.00	0.30				
		DHW(gas) (3)	S S/S	5.00				3			375.00	0.37				
251	P	Evap Clr (5)	DC,DL		495.00	3.00	69.30	5	5		1435.00	0.04				
		Pack AC w/ Stm reheat	S S/S,DC,DL	5.20	268.00	7.20	153.38	1	1		287.00	1.00	0.74			
		HVAC, OA off	D/N,DC,DL	30.39	359.00	2.40	43.92	1	2		449.00	3.35	2.69	2.67		
		UH, TASA	D/N,DC,DL	737.93	2153.00	14.40	263.52	1	2		449.00	70.04	56.32	55.91		
253	P	UH(elec) (5)	D/N,DC,DL		12662.00	25.00	457.50	5	10		2245.00	0.72	0.59	0.58		
		Window AC	DC,DL		132.00	0.80	17.18	1	1		287.00	0.05				
		Evap Clr	DC,DL		66.00	0.40	9.24	1	1		287.00	0.03				
		DHW(elec) (2)	S S/S,DL		96.00	5.00	62.10	2			250.00	0.03				
255	P	Window AC	DC,DL		264.00	1.60	34.37	1	1		287.00	0.11				
		Heater(gas)	D/N	26.10				1	1		287.00	3.34	2.48	2.46		
257	P	HVAC, Bay 3	D/N,DC,DL	46.13	755.00	30.00	636.77	1	2		449.00	5.75	4.62	4.59		
		Htr, Bay 3 (8)	D/N	776.55				8	8		2296.00	12.41	9.22	9.13		
		HVAC, Bay 4	DC,DL		101.00	0.30	6.44	1	1		287.00	0.04				
		Htr, Bay 4 (15)	D/N	793.28				15	15		4305.00	6.76	5.02	4.98		
		Htr, Bay 5 (4)	D/N	804.30				4	4		1148.00	25.71	19.10	18.92		
		DHW(gas)	S S/S	1.00				1			125.00	0.22				
		DHW(elec)	S S/S,DL		16.00	1.30	16.15	1			125.00	0.01				
300	P	Calib. Labs	D/N,S S/S,DC,DL	174.75	4138.00	1.20	49.68	3	3		861.00	8.16	6.06	6.00		
			Page Totals	8167.41	36011.00		3598.63	107	147		41755.00					

+ Equip recommended for EMCS

TABLE 4.3 (Cont'd)

Bldg No.	T or P	Equipment Controlled	EMCS Programs	Energy Savings Gas (MB/Yr)	Energy Savings Elect (KWH/Yr)	Equip Demand (KWH)	Demand Savings ($/Yr)(*1)	Receiver Units (ea.)	Hi/Lo T'Stat (ea.)	Add'n Equip (note *)	Field Costs ($)(*2)	SIR Iteration #1	#2	#3	#4	#5
320*	P+	Stm Htg	D/N	3269.40				1	3	4(3)	3145.00	49.52	47.57	47.50		
		HV Unit (7)	DC,DL		8372.00	56.00	1024.80	7	7		2009.00	0.49				
		AC, Avion & Tele	DC,DL		462.00	2.80	60.14	2	2		574.00	0.09				
		Evap Clr (2)	DC,DL		1006.00	3.20	73.92	2	2		574.00	0.20				
		Pack AC (10)	DC,DL		1056.00	6.40	137.47	10	10		2870.00	0.04				
325	P+	HVAC	D/N,DC,DL	126.30	755.00	30.00	636.77	1	2		449.00	15.36	12.35	12.26		
		DHW(gas)	S S/S	0.60				1			125.00	0.13				
330	P	Window AC	DC,DL		99.00	0.60	12.89	1	1		287.00	0.04				
348	P	Evap Clr (9)	DC,DL		594.00	3.60	83.16	9	9		2583.00	0.03				
		Window AC	DC,DL		231.00	1.40	30.07	1	1		861.00	0.04				
		DHW(elec) (3)	S S/S,DL		162.00	11.00	136.62	3			375.00	0.04				
351	P	Pack AC (2)	DC,DL		252.00	0.80	33.12	2	1		574.00	0.05				
		DHW(elec)	S S/S,DL		38.00	3.00	37.26	1			125.00	0.03				
352	P	Window AC	DC,DL		132.00	2.80	60.14	1	1		287.00	0.05				
		DHW(elec)	S S/S,DL		31.00	1.50	18.63	1			125.00	0.02				
353	T+	Stm Htg	D/N	142.13				1	1	4	1048.00	6.10	5.46	5.44		
		Evap Clr (4)	DC,DL		264.00	1.60	36.96	4	4		1148.00	0.03				
		Pack AC	DC,DL		132.00	10.00	214.80	1	1		287.00	0.05				
		DHW(gas)	S S/S	1.30				1			125.00	0.29				
354	P+	Stm Htg	D/N	24.30				1	1	4	1048.00	1.04	0.93	0.93		
		Window AC	DC,DL		33.00	0.20	4.30	1	1		287.00	0.01				
		DHW(elec)	S S/S,DL		48.00	1.50	18.63	1			125.00	0.03				
355	P+	Stm Htg	D/N	332.18				1	1	4	1048.00	14.25	12.76	12.71		
			Page Totals	3896.21	13667.00		2619.68	54	48		20079.00					

+ Equip recommended for EMCS

TABLE 4.3 (Cont'd)

Bldg No.	T or P	Equipment Controlled	EMCS Programs	Energy Savings Gas (MB/Yr)	Energy Savings Elect (KWH/Yr)	Equip Demand (KWH)	Demand Savings ($/Yr)(#1)	Receiver Units (ea.)	Hi/Lo T'Stat (ea.)	Add'n Equip (note #)	Field Costs ($)(#2)	Savings to Investment Ratio (SIR) Iteration (#3) #1	#2	#3	#4	#5
355	P	UH (9)	DC,DL		837.00	5.60	102.48	9	9		2583.00	0.06				
		Window AC (3)	DC,DL		231.00	1.40	30.07	3	3		861.00	0.05				
		Evap Clr (2)	DC,DL		264.00	1.60	36.96	2	2		574.00	0.08				
		DHW(elec)	S S/S,DL		88.00	8.00	99.36	1			125.00	0.09				
360	P+	Htr(gas) (2)	D/N	46.05				2	2		574.00	2.94	2.19	2.17		
		Evap Clr	DC,DL		132.00	0.80	18.48	1	1		287.00	0.08				
		Window AC	DC,DL		44.00	0.30	5.67	1	1		287.00	0.03				
361	P	UH	DC,DL		29.90	0.20	3.66	1	1		287.00	0.02				
382	T+	Stm Htg	D/N	151.20				1	1	4	1048.00	6.48	5.81	5.79		
		UH (3)	DC,DL		90.00	0.60	10.98	3	3		681.00	0.02				
		Evap Clr (3)	DC,DL		198.00	1.20	27.72	3	3		861.00	0.04				
420	P+	Stm Htg (3)	D/N	425.18				3	3	4(3)	2284.00	8.11	7.02	6.99		
		UH (3)	DC,DL		721.00	4.80	87.84	3	3		861.00	0.15				
		Window AC	DC,DL		99.00	0.60	12.89	1	1		287.00	0.06				
		DHW(elec)	S S/S,DL		60.00	4.50	55.89	1			125.00	0.06				
423	P+	UH(gas) (8)	D/N,DC,DL	235.35	319.00	2.10	38.43	8	16		3592.00	2.71	2.18	2.17		
		Heat Pump	DC,DL		38.00	3.30	109.10	1	1		287.00	0.02				
		DHW(gas)	S S/S	0.40				1			125.00	0.09				
439	T	DHW(elec)	S S/S,DL		599.00	4.50	55.89	1			125.00	0.63				
452	P+	UH(gas) (4)	D/N,DC,DL	345.83	96.00	0.60	10.98	4	8		1796.00	7.81	6.28	6.24		
		Window AC	DC,DL		44.00	0.30	5.67	1	1		287.00	0.03				
		DHW(gas)	S S/S	0.60				1			125.00	0.13				
			Page Totals	1204.61	3889.90		712.07	52	59		18062.00					

+ Bldgs recommended

TABLE 4.3 (Cont'd)

Bldg No.	T or P	Equipment Controlled	EMCS Programs	Energy Savings Gas (MB/Yr)	Energy Savings Elect (KWH/Yr)	Equip Demand (KWH)	Demand Savings ($/Yr)(*1)	Receiver Units (ea.)	Hi/Lo T'Stat (ea.)	Add'n Equip (note *)	Field Costs ($)(*2)	Savings to Investment Ratio (SIR) Iteration (*3) #1	#2	#3	#4	#5
551	T	UH(gas) (4)	DC,DL		24.00	0.20	3.66	4	4		1148.00	0.00				
		Evap Clr (4)	DC,DL		264.00	1.60	36.96	4	4		1148.00	0.03				
		DHW(gas)	S S/S	0.80				1			125.00	0.18				
555	P	Chiller # 1	DL			56.90	1610.84	1			125.00	0.00				
	+	AH-1	DC,DL		3780.00	6.00	248.40	1	1		287.00	1.54	1.14	1.13		
		Pack AH-2	DC,DL		1512.00	14.00	293.09	1	1		287.00	0.62				
		Chiller # 3	DL			48.00	1358.89	1			125.00	0.00				
		AH-4	DC,DL		756.00	1.20	49.68	1	1		287.00	0.31				
	+	Main AH (SF & RF)	DC,DL		10080.00	16.00	662.40	1	1		287.00	4.10	3.05	3.02		
		Pack AH-5	DC,DL		1008.00	10.40	232.56	1	1		287.00	0.41				
		AH-6	DC,DL		1512.00	2.40	99.36	1	1		287.00	0.62				
		Comp/Cond (2)	DL			5.60	120.29	2			250.00	0.00				
		All HVAC	D/N	791.25	134030			6	12		5870.00	8.46	7.53	7.49		
		DHW(gas)	S S/S	0.70				1			125.00	0.15				
600	P+	Gas Furn	D/N,DC,DL	51.45	189.00	0.60	10.98	1	1		287.00	6.83	5.07	5.02		
		Pack AC	DL			4.40	94.51	1	1		125.00	0.00				
		DHW(gas)	S S/S	0.30				1			125.00	0.07				
603	T	Gas Furn	DC,DL		189.00	0.60	10.98	1	1		287.00	0.08				
		Pack AC	DL			2.60	54.99	1	1		125.00	0.00				
		DHW(elec)	S S/S,DL		24.00	4.50	55.89	1			125.00	0.02				
650	P+	H.W. Htg	D/N	919.73				1	1		287.00	117.62	87.36	86.52		
	+	HV & UH (2)	D/N,DC,DL	326.40	239.00	1.60	29.28	2	4		898.00	14.89	11.97	11.88		
		Evap Clr (7)	DC,DL		4224.00	25.60	582.12	7	7		2009.00	0.25				
652	P+	Gas Furn	D/N,DC,DL	69.75	90.00	0.60	10.98	1	2		449.00	6.43	5.17	5.13		
		Evap Clr	DC,DL		99.00	0.60	13.86	1	1		287.00	0.04				
		DHW(gas)	S S/S	0.50				1			125.00	0.11				
			Page Totals	2160.88	158020		5579.72	45	45		15767.00					

+ Equip recommended for EMCS

TABLE 4.3 (Cont'd)

Bldg No.	T or P	Equipment Controlled	EMCS Programs	Energy Savings Gas (MB/Yr)	Energy Savings Elect (KWH/Yr)	Equip Demand (KWH)	Demand Savings ($/Yr)(#1)	Receiver Units (ea.)	Hi/Lo T'Stat (ea.)	Add'n Equip (note #)	Field Costs ($)(#2)	Savings to Investment Ratio (SIR) Iteration (#3) #1	#2	#3	#4	#5
654	T	Evap Clr	DC,DL		66.00	0.40	9.24	1	1		287.00	0.03				
656	T+	Htr(gas) (2)	D/N	35.85				2	2		574.00	2.29	1.70	1.69		
658	T	Wall AC (2)	DC,DL		751.00	4.50	96.66	2	2		574.00	0.15				
		Evap Clr	DC,DL		66.00	0.40	9.24	1	1		287.00	0.03				
660	T	Evap Clr (2)	DC,DL		132.00	0.80	18.48	2	2		574.00	0.03				
663	T+	Htr(gas) (2)	D/N	6.15				2	2		574.00	0.39	0.29	0.29		
		Evap Clr (2)	DC,DL		132.00	0.80	18.48	2	2		574.00	0.03				
664	T	Evap Clr	DC,DL		22.00	0.30	3.46	1	1		287.00	0.01				
666	T	Evap Clr (2)	DC,DL		66.00	0.80	9.24	2	2		574.00	0.01				
668	T	Evap Clr (2)	DC,DL		66.00	0.80	9.24	2	2		574.00	0.01				
670	T	Evap Clr (2)	DC,DL		66.00	0.80	9.24	2	2		574.00	0.01				
		DHW(gas)	S S/S	0.70				1			125.00	0.15				
672	T+	Htr(gas) (7)	D/N	119.10				7	7		2009.00	2.18	1.62	1.60		
		Wall AC (2)	DC,DL		528.00	3.20	68.74	2	2		574.00	0.11				
		DHW(gas)	S S/S	0.80				1			125.00	0.18				
675	P	DHW(gas)	S S/S	0.50				1			125.00	0.11				
680*	P	H.V. (5)	DC,DL		150.00	1.00	18.30	5	5		1435.00	0.01				
		Pack AC (2)	DC,DL		132.00	8.80	189.02	2	2		574.00	0.03				
		Evap Clr	DC,DL		44.00	0.30	6.93	1	1		287.00	0.02				
		DHW(gas)	S S/S	0.60				1			125.00	0.13				
			Page Totals	163.70	2221.00		466.27	40	36		10832.00					

+ Equip recommended for EMCS

TABLE 4.3 (Cont'd)

Bldg No.	T or P	Equipment Controlled	EMCS Programs	Energy Savings Gas (MB/Yr)	Energy Savings Elect (KWH/Yr)	Equip Demand (KWH)	Demand Savings ($/Yr)(*1)	Receiver Units (ea.)	Hi/Lo T'Stat (ea.)	Add'n Equip (note *)	Field Costs ($)(*2)	Savings to Investment Ratio (SIR) Iteration (*3) #1	#2	#3	#4	#5
682	P+	HV (2)	D/N,DC,DL	95.85	80.00	0.50	9.15	2	4		898.00	4.37	3.52	3.49		
		FC (2)	DC,DL		198.00	1.20	27.72	2	2		574.00	0.04				
		Comp/Cond (2)	DL			16.80	360.86	2			250.00	0.00				
		DHW(gas)	S S/S	0.80				1			125.00	0.18				
690,692, 694	P+	H.W. Htg (3)	D/N	213.98				3	3		861.00	9.12	6,77	6.71		
		Evap Clr (6)	DC,DL		907.00	2.40	55.44	6	6		1722.00	0.06				
		Window AC (4)	DC,DL		403.00	1.10	23.63	4	4		1148.00	0.04				
		DHW(gas) (3)	S S/S	1.40				3			375.00	0.10				
698	P	Htr(elec)	DC,DL		598.00	0.40	7.32	1	1		287.00	0.24				
		Evap Clr	DC,DL		33.00	0.20	4.62	1	1		287.00	0.01				
699*	P	Evap Clr	DC,DL		44.00	0.30	69.30	1	1		287.00	0.02				
		DHW(elec)	S S/S,DL		64.00	4.50	55.89	1			125.00	0.05				
			Page Totals	312.03	2327.00		613.93	27	22		6939.00					
			Grand Totals for EMCS	18276.01	344402		9005.73	172	265		89419.00					

+ Equip recommended for EMCS

CHAPTER 5

RENEWABLE ENERGY SOURCES (Incr. C)

Reference

5.1 SCOPE

The following potential energy sources were investigated for possible use at SAAD. Vol. 1 Sec. 6.1

- Bituminous Coal
- Wind
- Biomass including:

    Wood Pellets
    On-Post Waste
    On-Post Refuse
    Off-Post Wood By-Products
    Off-Post Wood Chips
    Off-Post Refuse

- Solar Heat
- Purchased Steam

The results and recommendations of the analyses follow.

5.2 COAL

Coal prices (currently $2.65/MB) are forecast by the California Energy Commission to remain below those of oil and gas. Low-cost reserves are extensive, so that mining costs should not rise much as a result of depletion. Competition among sellers, combined with utility bargaining power, should keep prices from rising to the levels of oil or gas prices. According to the CEC, the greatest potential for cost increases stems from the monopoly power of the railroads--some part of the route from any coal field to California is controlled by a single railroad. Coal is readily available with no reason to believe that there will be any change in the near future. DOE has projected a 13.9% per annum rise in cost (discounting inflation) from 1981-85 and 1.3% per annum rise from 1985-90. The CEC projects an average rise of 3% per annum (above inflation) from 1985-90. Vol. 1 Sec. 6.2

Reference

Availability and cost make coal an attractive alternative to natural gas. It is recommended that coal be considered as a future source of solid fuel.

5.3 WIND ENERGY

Electrical energy production using commercially available wind turbines is not a viable energy alternative at SAAD. Based on wind data from Sacramento Executive Airport (approx. 5 miles from SAAD) analysis resulted in an SIR of 0.36 and a simple payback of 33 years. — Vol. 1 Sec. 6.3

5.4 BIOMASS

The following known on- and off-Post biomass resources were investigated: — Vol. 1 Sec. 6.4.1

- Wood Pellets
- On-Post Waste (wood pallets)
- On-Post Refuse (cardboard, paper, foam)
- Off-Post Wood By-Products
- Off-Post Wood Chips
- Off-Post Refuse (residential garbage)

Table 5.1 shows the quantities available and the estimated cost of the various biomass resources.

5.4.1 Wood Pellets

Wood pellets are considered one of the higher quality biomass resources due to the uniformity of size (generally 3/4" to 1-1/2" by 1/4 to 1/2" diameter) and heat content (8500-8800 Btu/lb) which result in easier handling and more stable combustion. The nearest manufacturer of wood pellets, Modoc Lumber Company, is located approximately 300 miles from SAAD in Klamath Falls, Oregon. Their present quoted price is $55/ton ($3.20/MB) without transportation. Assuming $45/hr per 25 ton live floor truck delivery costs would add $1.80/MB for a total delivered price of $5.00/MB. — Vol. 1 Sec. 6.4.1.1

TABLE 5.1

SUMMARY OF BIOMASS AVAILABILITY & DELIVERED COST

Source	Quantity (tons/yr)	Heat (Btu/lb)	Total MB/yr	Cost $/MB At Source	Cost $/MB Transport	Revenue	Total	Remarks
Wood Pellets	Unlimited	8,600	-	3.20	1.80	0	5.00	
On-Post Waste	1,300	8,000	20,800	0	0	0.38	-0.38	Per telcon 5/4/83 w/Mr. Dallas Berry, supervisor Roads & Grounds.
On-Post Refuse	1,650	7,000	23,100	0	0	1.90	-1.90	Per telcon 5/3/83 w/Dallas Berry & Bea Woodward of Resource Management
Off-Post Wood	200,000	8,000	3,200,000	-	-	-	1.16-1.65	Per telcon with various suppliers.
Off-Post Wood chips (forest residue & orchard prunings)	1,681,400	8,500	28,584,000	-	-	-	3.00	Per telcon 5/3/83 w/Gene West, wood chip dealer, Nevada City & forestry services.
Off-Post Refuse	650,000	4,500	5,850,000	0	0	0	0	Per telcon 5/2/83 w/Mr. George Lynch Public Works Dept.
	2,543,400		37,678,000					

Reference

5.4.2 On-Post Waste

SAAD currently disposes of approximately 1,300 tons/yr of used wooden pallets and recycles 90 tons/yr of computer printouts. Vol. 1 Sec. 6.4.1.2

The wood pallets are currently given to a local wood chip dealer (Kelbro in Sacramento) who chips and sells the product as a heating fuel or as charcoal briquet stock. The cost of hauling the pallets to Kelbro is estimated at $7,800/yr.

According to Mr. Dallas Berry of Roads & Grounds, SAAD now recycles 90 tons/yr of computer printouts. However, the computer printouts will soon be changed to a smaller, carbonless type of paper that is disposable which will drop the recycled tonnage by 50-60% and increase the refuse tonnage accordingly.

5.4.3 On-Post Refuse

According to Ms. Bea Woodward of Resources Management, SAAD disposed 58,000 yards of refuse in the county landfill in FY 82 at a cost of $44,100. Mr. Berry of Roads and Grounds indicates that the bulk of the refuse is cardboard packaging, foam, paper waste and plastic wrapping. On KE's request Mr. Berry weighed several truckloads of refuse and determined that the average weight is 4.8 tons/load. At 7 loads/week; 52 wk/yr this equates to 1750 tons/yr. Assuming 95% combustibles (per visual inspection) SAAD generates approximately 1,650 tons/yr of combustible material. Vol. 1 Sec. 6.4.1.3

5.4.4 Off-Post Wood By-Products

Many sources of off-post wood byproducts were located in the Sacramento area. The companies located, source of fuel, fuel cost, approximate tonnage available and cost per million Btu's are shown in Table 5.2. The companies indicated there would be no difficulty in supplying SAAD with their current thermal* requirements (equivalent to 8,200 dry tons/yr)*. Vol. 1 Sec. 6.4.1.4

Reference

$$* \quad 140{,}000 \frac{MB}{Yr} \times \frac{10^6 B}{MB} \times \frac{1lb}{8500B} \times \frac{1\ ton}{2000lb} = 8{,}200\ ton/yr$$

Three companies generate wood chips as a by-product of another process and thus can offer their wood chips for less than the companies that sell chips as their main product. The byproduct wood chips are a relatively constant source and the prices will tend to rise if there is a marked increase in demand. If the demand becomes great enough, the prices will approach the price quoted by the wood chip dealers which is $3.00/MB. Vol. 1 Sec. 6.4.1.4

The major users of Off-Post wood byproducts are currently Imotek (for a biomass fueled power plant) in Sacramento, Kingsford Briquets in Elk Grove and Louisiana Pacific (for biomass fueled power plant) in Antioch.

According to Mr. Ray Rasmussen of the Tera Corporation, a local wood recycler, approximately 100-150,000 dry tons per year of wood byproducts are available in the Sacramento area at a cost of $1.65/MB, most of which go unused due to the supply of lower cost wood byproducts.

TABLE 5.2

OFF-POST WOOD CHIPS

Supplier	Fuel Type	Delivered cost for chipped wood	Cost Per MB	Approximate dry tonnage available per year
Kelbro	Mill Waste	$5.50/yd^3	1.16	50-100,000
Tera Corporation	Building Demolition, Landfill wood waste	$28/dry ton	1.65	100-150,000
Cal Wood Fiber	Tree Bark	$22/dry ton	1.28	10-20,000

Reference

5.4.5 Off-Post Wood Chips

Two potential sources of off-post wood chips were investigated, fruit and nut tree residue and forest residue. Vol. 1 Sec. 6.4.1.5

Table 5.3 indicates the approximate annual tonnages available in Sacramento County and the eight surrounding counties. The bulk of these are from prunings located in San Joaquin County which lies 60 miles south of SAAD. The delivered cost of almond prunings is expected to be \$20-30/green ton (\$1.75-2.63/MB).(1)

TABLE 5.3

Orchard Prunings(2)

	Dry ton/yr		Dry ton/yr
Almonds	46,600	Peaches	23,400
Apples	1,800	Pears	15,300
Apricots	10,800	Plums	1,700
Cherries	2,400	Walnuts	35,600
Grapes	81,000		
		Total	235,400

The closest forest residue wood chip dealer, Gene West of Nevada City has indicated that he could supply SAAD with a virtually unlimited amount of wood chips. The delivered price for the wood chips would be \$30/green ton (\$3.00/MB). Mr. West obtains his wood chips through forest thinning contracts with private firms. The bulk of Mr. West's 1982 production of 58,000 green tons was shipped to a 20 MW power plant in Contra Costa County operated by Louisiana Pacific. The delivered cost per MB is unknown, however California Wood Fiber has indicated that Louisiana Pacific's standard offer is approximately \$1.10-\$1.30/MB. Vol. 1 Sec. 6.4.1.5

(1) Almond Board of California; 1980-81 Almond Research Progress Report.

(2) Agricultural Residue in California, U.C. Davis leaflet 21303.

Reference

Quantitative figures for logging slash and other unmarketable forest residue are not well documented, however, with the help of the California Department of Forestry and the U.S. Department of Forestry, approximate figures for Nevada, Eldorado, Amador, Placer and Calaveras counties were compiled and are shown in Table 5.4.

TABLE 5.4

Estimated Annual Forest Residue Available In 8 Surrounding Counties

	Dry Tons	
		Vol. 1 Sec. 6.4.1.5
Mill Residue	491,700	
Precommercial Thinning (4"-11")		
Tahoe National Forest	31,900	
Eldorado National Forest	5,300	
Private Timberland	27,100	
Logging Slash		
Eldorado County	303,000	
Placer County	156,400	
Amador County	52,500	
Nevada County	72,900	
Calaveras County	80,800	
Dead/dying trees (insects, disease, weather)	224,400	
	1,446,000	

Sources: California Forests: Trends, Problems and Opportunities, USDA

Wood Energy, CDF

It should be noted that the quantities of mill residue, logging slash and off-post wood byproducts are highly dependent on the building construction industry. The figures presented are for 1976, an average year in which 4.7 billion board feet of lumber were produced.

Reference

5.4.6 Off-Post Refuse

According to Mr. George Lynch of the Sacramento County Public Works Department the Sacramento County landfill acquires approximately 1,500 tons/day of refuse and the city landfill acquires 700 tons/day of refuse. Private landfills receive an additional 500-700 tons/day. Vol. 1 Sec. 6.4.1.6

A number of projects have been proposed to utilize a portion of the refuse. The most notable is a project proposed by the Sacramento Municipal Utilities District (SMUD) to build a power plant fueled by 600-700 tons/day of refuse (feasibility study awarded to Bechtel in May, 1983). Mr. Lynch indicated that there is adequate refuse at no cost to support many more projects.

5.4.7 Recommendations

On-post waste, on-post refuse, off-post wood by-products and off-post wood chips are the most attractive biomass sources available to SAAD. On-post biomass sources are capable of supplying SAAD with 80% of their future heating needs. Off-post biomass sources can provide many times what is needed on-post at a present cost of $1.65 per million Btu (1/3 the price of natural gas). Vol.1 Sec. 6.4.3

It is recommended that these sources of fuel be used in the proposed solid fuel boiler plant (which would include an incinerator with heat recovery boiler) as the primary fuel. Coal would be used as a supplementary fuel to keep the boilers running at full output when the moisture content of the wood fuel becomes excessively high or when the cost of off-post wood sources approaches that of coal.

Off-post refuse is not recommended due to the poor fuel quality, difficult fuel handling and abundant sources of higher quality fuel.

The use of wood pellets is not recommended due to cost.

Reference

5.5 SOLAR HEATING

Three types of solar heating systems were investigated: Vol. 1 Sec. 6.5

- Domestic Hot water heating for offices and residences
- Make-up water pre-heat system for the boiler plant
- Space heating system for building 348

For each type of solar heating system two types of sub-systems were analyzed:

- Active (automatically controlled, no user involvement required)
- Passive (user involvement is required to make system operate)

The two most cost effective systems analyzed have SIR's of 0.42 (an active flat-plate collector system for building 320) and 0.40 (boiler makeup water preheat system). These two systems have a simple payback period of 33 years and an annual cost savings of $1,900. These projects can not be currently recommended although they may become economically feasible if natural gas deregulation causes prices to escalate faster than currently predicted.

5.6 PURCHASED STEAM

5.6.1 Overview

A Proctor & Gamble (P&G) processing plant, located directly across the street from SAAD on Fruitridge Road, is currently planning to install a 21 MW gas turbine cogeneration system which will produce 70,000 lb/hr of 150 psig steam. Vol. 1 Sec. 6.6.1

Mr. Cottrell, the Plant Engineer, has indicated that the proposed system should have sufficient capacity to sell 5-10,000 lb/hr of 90 psig steam. At the time of this printing the proposed system was in such an early stage of development that Mr. Cottrell could not quote a price on the steam. The steam price will be a function of the price that P. G. & E. pays for the cogenerated electricity and the price Proctor & Gamble pays for the gas turbine fuel.

Reference

Proctor & Gamble is entering into a contract with a private gas supply firm to purchase gas at substantially lower rates than P.G. & E. offers ($3.00-$3.50 per MB vs. P.G. & E.'s $5.00-$5.50). With this favorable fuel cost, the cost to generate electricity would be around 3 ¢/KWH. P.G. & E. currently pays cogenerators 5.85 ¢/KWH leaving Proctor & Gamble a gross profit of 2.85 ¢/KWH. With this favorable cogeneration rate, Proctor & Gamble will want to generate as much electricity as possible which means there will be an excess supply of steam. Therefore, it would be advantageous to Proctor & Gamble to sell SAAD as much of the excess steam as possible.

5.6.2 Conclusions & Recommendations

We estimate the cost of installing a 5" steam line and 3" condensate between SAAD and Proctor & Gamble to be approximately $300,000. Without displacing a boiler this investment could not be recovered even if P&G decided to give the steam to SAAD free. Vol. 1 Sec. 6.6.3

If the steam supply was dependable enough and large enough to displace one of the new proposed boilers (Chpt.7) the project might pay for itself depending on the purchased price. However it is unlikely that the Depot would want to put itself in the position of being dependent on an outside source without 100% backup of its own.

It is not recommended that SAAD purchase this source of energy.

5.7 RENEWABLE ENERGY SOURCE RECOMMENDATIONS

The most attractive resources available to SAAD are coal, on-post waste, on-post refuse, off-post wood by-products and off-post wood chips. Vol. 1 Sec. 6.4.3

On-post waste and on-post refuse is recommended for use in the proposed incinerator/waste heat boiler project (see Chpt.3) while off-post wood chips and off-post wood by-products are recommended for use in the proposed solid fuel boiler plant (see Chpt.7). Coal is recommended as a supplementary fuel in case the moisture

Reference

content of the wood fuel is excessively high.

It is recommended that SAAD keep a one-year supply of coal (covered with turf or plastic sheathing) near the railroad siding in case of emergencies.

CHAPTER 6

COGENERATION, INCINERATION & GASIFICATION (Incr. D)

Reference

6.1 SCOPE

Increment D addressed the feasibility of installing a cogeneration system and/or a solid waste heating plant using solid fuels supplemented with refuse derived fuels and waste oils. Vol. 1 Sec. 7.1

The cogeneration system was required to use solid fuel (either biomass or coal) as the primary energy source and oil as a secondary source, if necessary.

The solid waste heating plant was required to use on-post refuse (off-post refuse, if feasible) to produce steam for space heating.

6.2 COGENERATION

Cogeneration is defined as the simultaneous production and use of thermal and electrical energy. The scope of the analyses was confined to the following: Vol. 1 Sec. 7.2

a. Primary fuel source is wood and coal with fuel oil as backup (see Chpt. 5 for conclusions regarding solid fuel energy sources).

b. The Army is willing to sell excess electricity to local utility company per the conditions established by the Pacific Utility Regulatory Policies Act of 1978 (PURPA).

c. Thermal and electric loads assume all Increment A, B, and F energy measures have been implemented and the central steam distribution system has been expanded to include most of the buildings on base (see Chpt. 3 for load profiles).

Referenc

6.2.1 Utility Company Contractual Arrangements

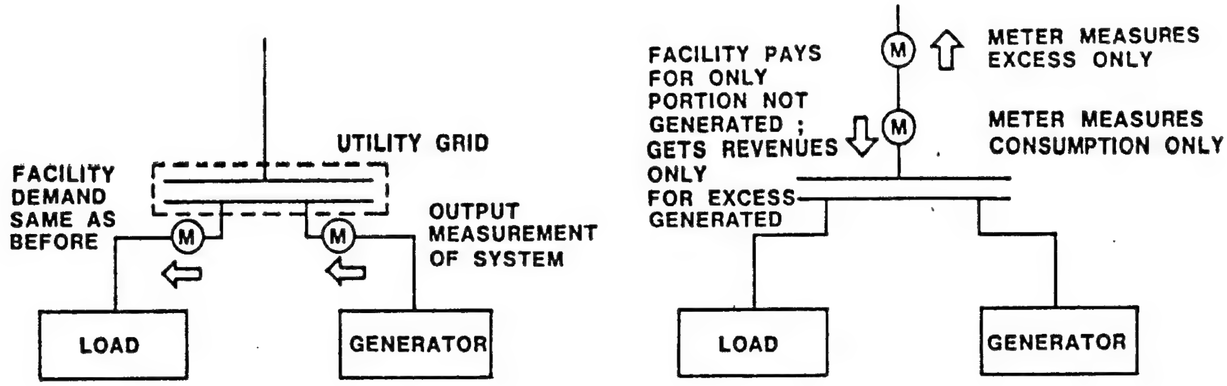
There are two basic types of "buy-back" arrangements for cogenerators; 1) Buy-all, Sell-all, and 2) Offset-load, Sell-surplus. In terms of system operation they are the same; the way in which the cogenerator is compensated is greatly different. The computer program used to model the various cogeneration options calculates system performance in both modes. Schematics of both modes are shown in Fig. 6-1 and 6-2. Vol. 1 Sec. 7.2.1.3.2

a. Buy-all, Sell-all (BASA): In this mode the cogenerator agrees to purchase all his electrical needs on exactly the same rate schedule as before. Therefore the cogenerator's electrical bill does not change. However, the utility agrees to buy all the electricity generated, regardless of quantity or time of day, at the agreed upon "avoided cost" rate structure. Standby charges are not normally part of the rate structure in this mode. The turbine/generator system in this case becomes a "profit center" whose objective is simply to minimize costs and maximize revenues.

b. Offset-load, Sell-surplus (OLSS): In this mode the cogenerator offsets his load with his system and therefore pays the utility only his net consumption. If he generates more than he uses, the utility buys only that excess at the agreed upon "avoided cost" rates. Standby charges are a part of the rate structure.

6.2.2 Calculations

Purchased electrical costs are calculated by the program using the "typical" hourly usage (KWH) and demand (KW) profiles developed from utility company records. The computer program modelled these costs based on an algorithm of the current billing structure. Table 6.1 lists the assumptions used. Vol. 1 Sec. 7.2.1.3.3

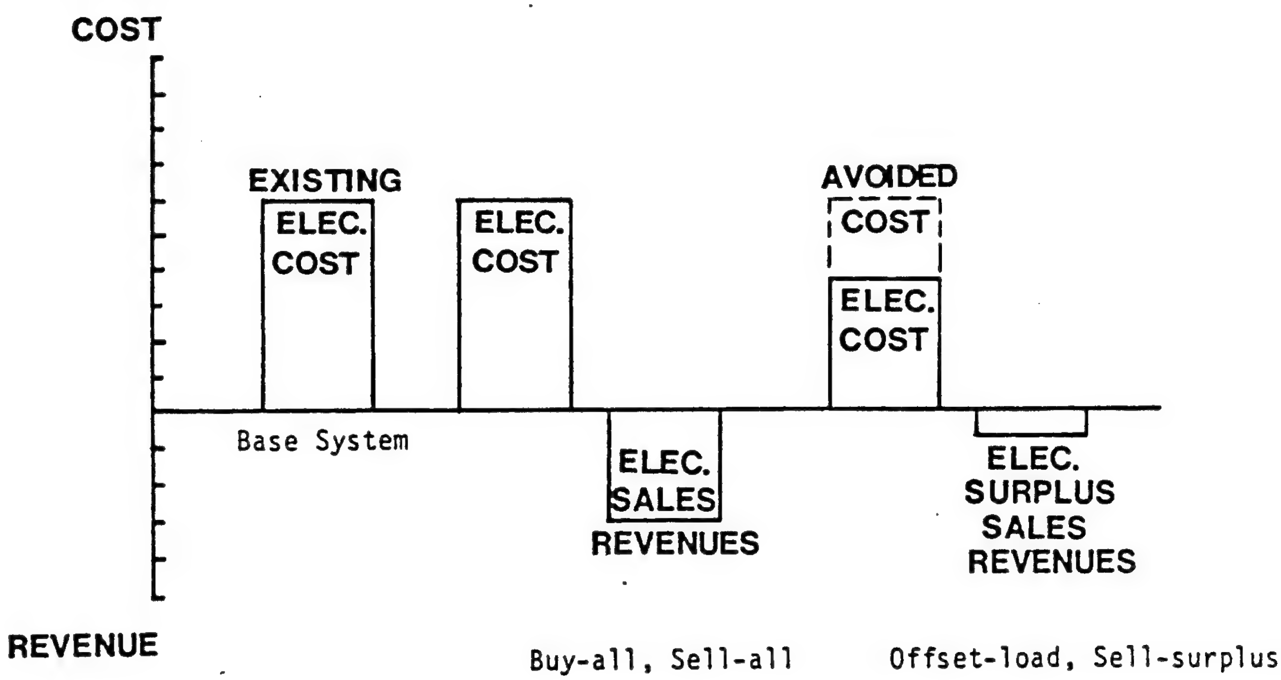


BUY–ALL, SELL–ALL
OPERATIONAL MODE

OFFSET–LOAD, SELL SURPLUS
OPERATIONAL MODE

COGENERATION OPERATIONAL MODES

FIG. 6-1



SCHEMATIC of ELECTRICITY COST & REVENUES

FIG. 6-2

TABLE 6.1

MAJOR COST ASSUMPTIONS

ELECTRICITY RATES [1]

- Purchase cost

Base Charge		\$23.50/mo
Demand Charge	(Nov-Apr)	\$ 3.05/KW-mo.
	(May-Oct)	\$ 3.85/KW-mo.
Usage Charge	(Nov-Apr)	\$ 0.0326/KWH(first 10,000 KWH)
		\$ 0.0151/KWH(over 10,000 KWH)
	(May-Oct)	\$ 0.0380/KWH(first 10,000 KWH)
		\$ 0.0151/KWH(over 10,000 KWH)

- Buy-back rate (per P.G. & E.)

Non-time of day	\$ 0.0585/KWH
Capacity credit	\$100/KW per yr

FUEL RATES

- Coal	\$2.65/MB
- Biomass	\$3.00/MB (high)
	1.65/MB (low)

(1) Rates based on the local utility Sacramento Municipal Utility District wheeling power to P.G.& E. (reference Vol. 1, Section 7.2.2.1.

6.2.3 Equipment Analyzed

Reference

The scope requirement to use solid fuel as the primary energy source limited the alternatives to 3 types of power cycles (see Fig. 6-3). Vol. 1 Sec. 7.2.3

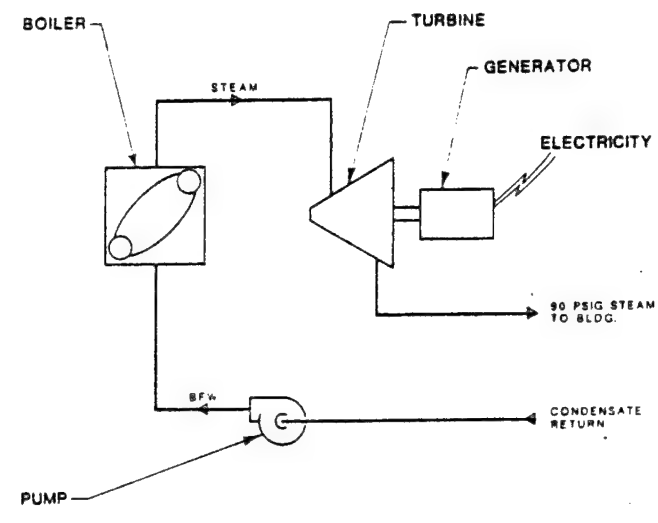
- Steam Rankine cycle (steam turbine)
- Direct Brayton cycle (gas turbine) or gas engine fueled by a low Btu producer gas from a gasifier.
- Indirect Brayton cycle (gas turbine with external combustor) powered by air from a boiler heat exchanger.

Gas turbines offer a higher electrical conversion efficiency (20-30%) than steam turbines (3-15%) which is in SAAD's favor since it's ratio of electrical-to-thermal energy use varies from 0.25 to 4.8 on a Btu basis. However, the requirement to use solid fuel adds a level of sophistication and associated problems to the scheme which industry has not yet solved. Though the use of gas turbines for cogeneration is becoming quite common (several under construction or already working in California) and reciprocating engines have been used for years, no low Btu fuel fired turbines or engines have been successfully operated. Solutions to solid fuel gasification problems appear to be 2-5 years in the future. Therefore, the cogeneration analysis for Sacramento Army Depot was confined to steam turbines exclusively.

6.2.4 Systems Analyzed

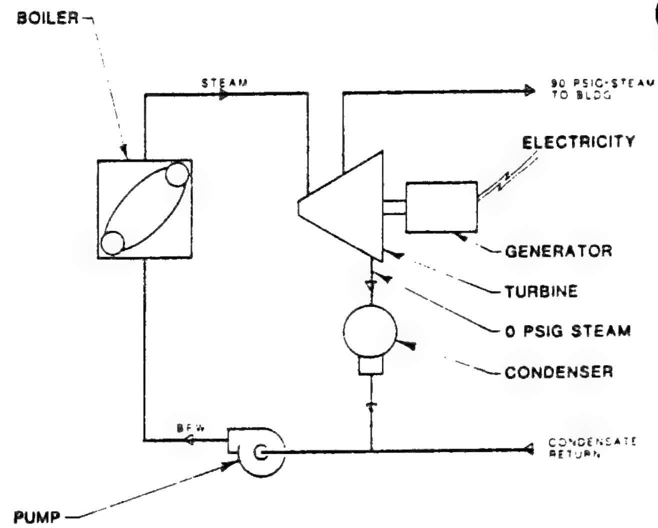
18 cases were preliminarily analyzed using single and multi-stage steam turbines at various pressures. Based on the conclusions of the preliminary screening two types of steam turbines were analyzed. Vol. 1 Sec. 7.2.4.1

- Single-stage back pressure turbine with all steam exhausting at 90 psig.
- Multi-stage extraction turbine with part of the steam extracted at 90 psig and the remainder going to condensers.



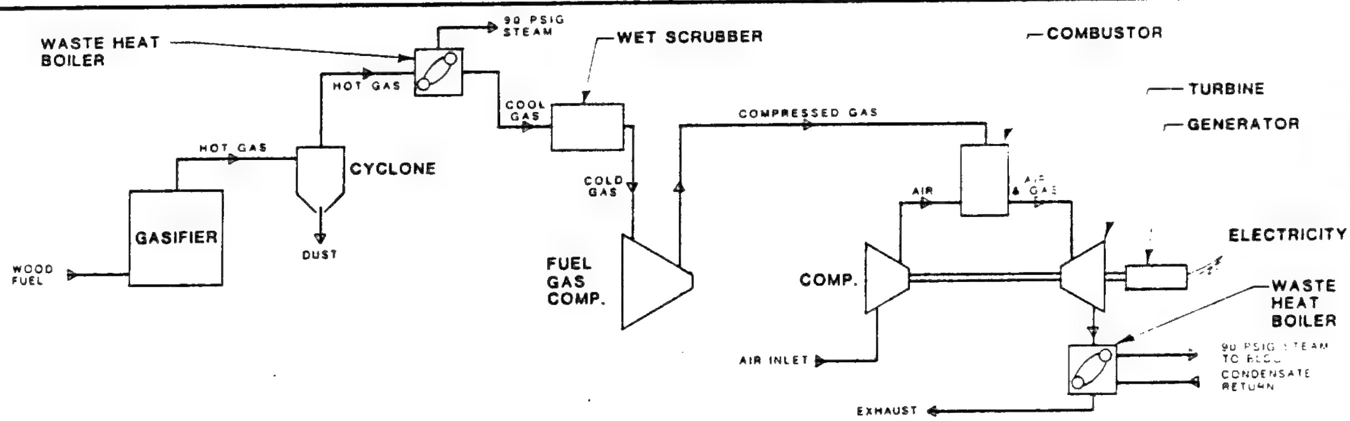
Single Stage Steam Turbine System

RANKINE CYCLE

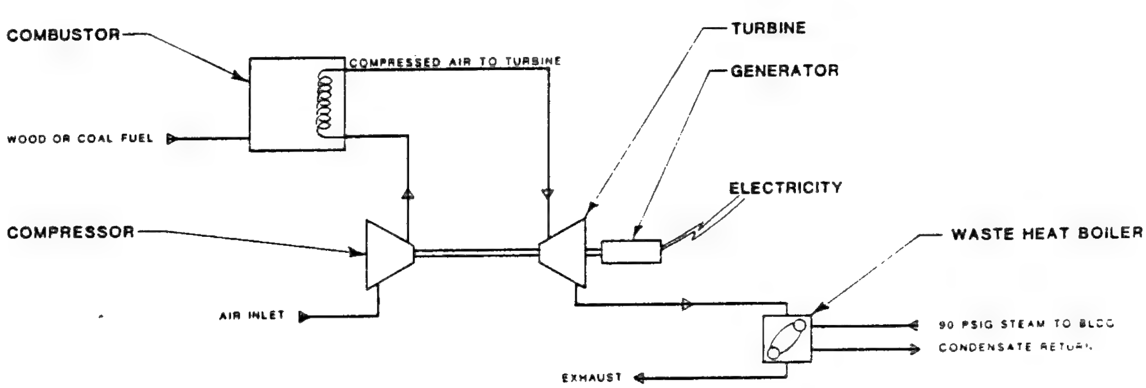


Multi-Stage Steam Turbine System

RANKINE CYCLE



Gasifier – Gas Turbine System BRAYTON CYCLE



Indirect Combustion Gas Turbine System BRAYTON CYCLE

affiliate of integrated energy systems	Koenigshofer Engineers energy consultants • designers Sacramento, CA	EP DK	RANKINE / BRAYTON CYCLE SCHEMATICS	FIG. 6-3

Reference

Each was computer modelled at various inlet pressures and flow rates and compared on an hourly basis to the post electrical and thermal needs to determine the usable and wasted energy. All electrical energy produced was either used by SAAD or sold to the utility company. Thermal energy was used as needed with the remainder going to waste. Unfortunately, the closer the system comes to matching SAAD's electrical needs, the more steam is wasted.

6.2.5 Fuel Costs Used

Although an adequate supply of cheap fuel is presently available ($1.65/MB for wood) indications are that demand will increase in the near future which will drive the price up to parity with the inexhaustible fuels. Since forest residule wood chips are relatively abundant its price ($3.00/MB) was considered the ceiling. All 18 cogeneration schemes were analyzed using both prices.

Vol. 1 Sec. 7.2.4.2

6.2.6 Conclusions

SAAD purchases electricity from the Sacramento Municipal Utilities District (SMUD) which is a relatively small utility district surrounded by a much larger utility district, Pacific Gas & Electric (P.G.& E.). SMUD is a municipally owned company whose source of generation is primarily hydroelectric and nuclear, whereas P.G.& E. is a privately owned company whose primary source of power is fuel oil. Consequently, P.G.& E.'s rates are 2 to 3 times as much as SMUD's (6-7 ¢/KWH vs. 2-3 ¢/KWH for large users). SMUD is the third cheapest metropolitan power company in the country (per Energy User News).

Because SMUD's power is generated from hydro or nuclear its cost of generation is low and therefore the buy-back rate offered to cogenerators is low (1-2¢/KWH). However, P.G.& E.'s cogeneration rates are relatively attractive (5-6 ¢/KWH). The net effect is that SAAD can actually buy electricity from SMUD for less than it can sell cogenerated electricity to P.G.& E.

SMUD is willing to "wheel" the power from SAAD to P.G.& E. for a small fee (0.1 ¢/KWH). Therefore, it is to SAAD's advantage to buy all of its power from SMUD and sell all of its cogenerated power to P.G.& E. Thus, all of the cogeneration schemes modelled used the buy-all, sell-all mode.

36 cogeneration systems were modelled (18 using $1.65/MB fuel, 18 using $3.00/MB fuel). 7 systems using $1.65/MB fuel qualified with SIR's over 1. No systems using $3.00/MB fuel qualified.

The 7 systems that qualified were all large systems that take advantage of the lower installed cost per KW. These systems qualified solely on the basis of being able to generate cheap electricity. Most of the heat is wasted which doesn't qualify the systems as cogeneration.

Table 6.2 presents the results of the two most attractive cogeneration options. The results are shown for both $1.65/MB and the $3.00/MB of fuel.

Reference

TABLE 6.2

SUMMARY OF FINAL COGENERATION ANALYSES

	Input				Output			
Case	Turbine	Fuel Cost	KW Peak	MWH	Total Fuel Cost(K$)	First Year Savings (K$)	Project Cost (K$)	SIR
12	Multistage 700 psig 750°F	$1.65/MB	5,489	45,583	2,158	993	9,663	1.51
		$3.00/MB	5,489	45,583	3,925	-666	9,663	<0
18	Multistage 900 psig 900°F	$1.65/MB	6,225	52,129	2,214	1,371	13,054	1.46
		$3.00/MB	6,225	52,129	4,025	-322	13,054	<0

6.2.7 Recommendations

Government owned solid fuel cogeneration is not recommended at SAAD for the following reasons: Vol. 1 Sec. 7.2.5

- Uncertainty of future fuel prices-if price of solid fuel rises above $2.00/MB the system will not pay for itself.

- Uncertainty of cogeneration rates-in the last 3 years P.G.& E. has decreased the rate it pays cogenerators for electricity 20%.

- Uncertainty of cogeneration legislation-utility companies are forced to purchase electricity from cogenerators by cogressional act (Public Utility Regulatory Policies Act-PURPA). If PURPA is changed or found illegal (cases pending) utility companies could (and probably would) stop purchasing electrcity from private cogenerators.

It is recommended that SAAD entertain proposals from private entrepreneurs to install privately

Referen

owned cogeneration on the base. With the tax advantages afforded private cogenerators an arrangement could be possible that would be advantageous to everybody.

It is also recommended that SAAD consider the gas fired turbine cogeneration system presented in Increment G.

6.3 INCINERATION

Controlled air incineration is the process of burning solid waste (fuel) under controlled conditions to produce heat which can be vented to the atmosphere or fed into a waste heat boiler. Incineration offers SAAD two advantages: Vol. 1 Sec. 7.3

- A large portion of SAAD's steam requirements can be met by using an incinerator/waste heat boiler system, thus reducing the boiler plant's natural gas usage.
- SAAD would eliminate existing disposal costs, since all on-post waste would be burnt in the incinerator.

6.3.1 Equipment Analyzed

Three types of incineration systems were considered:

- Controlled air incinerators
- Rotary kilns
- Fluidized bed incinerators

The rotary kiln and fluidized bed incinerators were dropped from consideration because they are not available in the small size range required (140 HP to 270 HP). SAAD has approximately 3,000 tons/yr of burnable refuse available.

6.3.2 Systems Analyzed

Three sizes of controlled air incinerators were analyzed to determine which was most economical. Vol. 1 Sec. 7.3.2

Reference

The boiler horsepower rating of the three systems ranged from 140 HP to 270 HP. The units are a ram fed cascading type of incinerator with induced draft waste heat boiler. The fuel handling system consists of a truck dump site from which the refuse is transferred by a front-end loader to a belt-fed shredder. A schematic of the system is shown in Fig. 6-4.

Each system was augmented with some amount of purchased wood chips to maximize the output of the incinerator. As the incinerator size increased the ratio of off-post fuel to on-post fuel increased. This modelling procedure was used in order to take advantage of the small incremental increase in price for larger units, i.e. an incinerator with 100% more capacity costs only 10% more to install.

Each system was simulated a second time assuming that the gas turbine proposed in Increment G had been installed. The gas turbine would produce the baseload steam requirements (4000 lb/hr) thus reducing the waste heat usage from the incinerators.

6.3.3 Conclusions & Recommendations

The SIR's for the 3 systems assuming no gas turbine ranged from 3.17 to 3.82, while the 3 cases assuming that the gas turbine had been installed ranged from 1.98 to 2.39 (see Table 6.3). Vol 1 Sec. 7.3.6

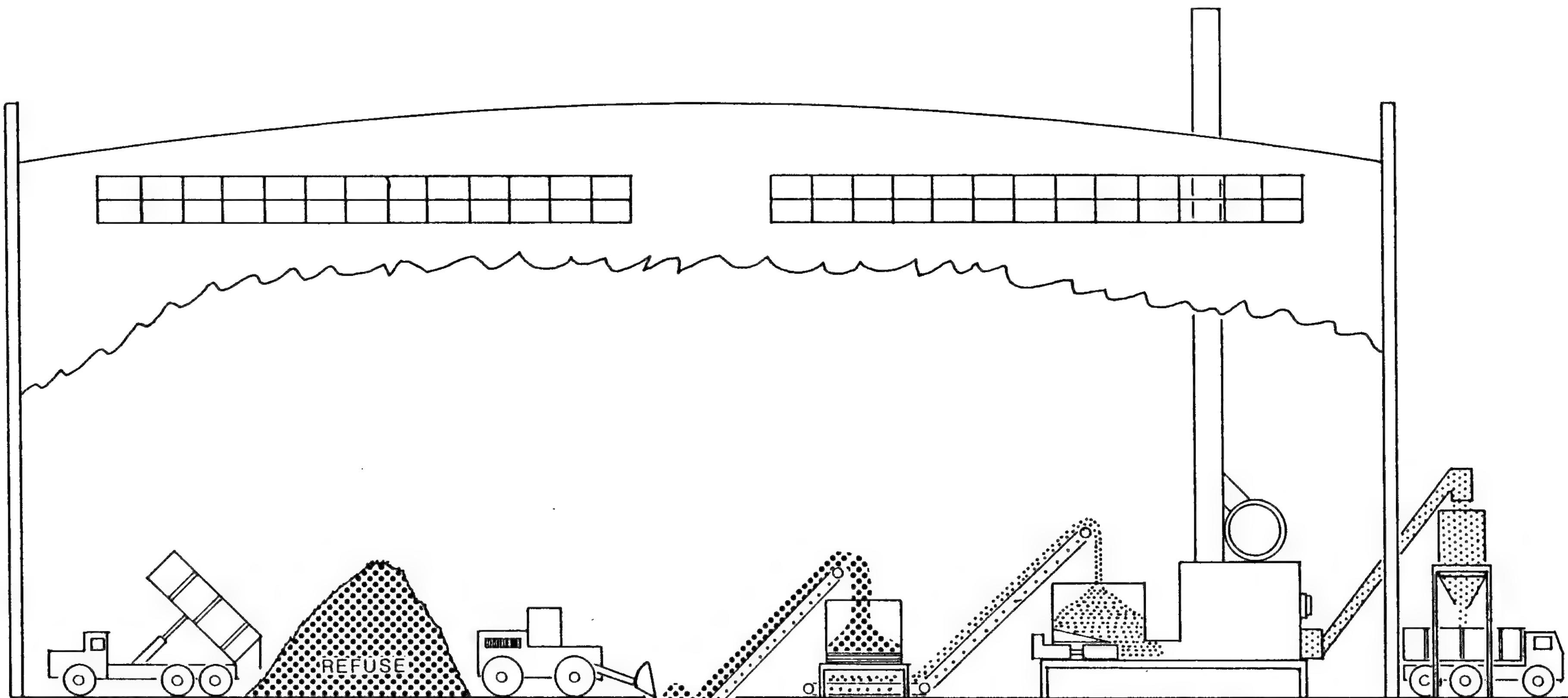
It is strongly recommended that SAAD install an incinerator/waste heat boiler system whether or not the gas turbine project proposed in Increment G is installed. The most cost effective system is Option 3 - 270 HP (9.1 MB/hr steam production) system shown in Table 6.3

TABLE 6.3

SUMMARY OF INCINERATION OPTIONS

Option	Incinerator Steam Prod. (MB/hr)	Capital Cost (K$)	Annual Savings W/O Turbine (MB/yr)	Annual Savings W/O Turbine (K$/Yr)	Annual Savings W/O Turbine SIR	Annual Savings W/Turbine (MB/Yr)	Annual Savings W/Turbine (K$/Yr	Annual Savings W/Turbine SIR
1	4.60	1,042	50,340	255	3.17	29,151	161	1.98
2	6.80	1,086	65,847	298	3.65	35,667	196	2.28
3	9.10	1,142	75,307	325	3.82	39,766	216	2.39

SACRAMENTO A. D.



INCINERATOR & WASTE HEAT BOILER FUEL HANDLING SYSTEM

FIG. 6-4

Reference

6.4 GASIFICATION

Gasification is a pyrolytic process whereby a solid fuel is subjected to high temperatures in the absence of sufficient oxygen for complete combustion to occur. The fuel is changed to a low Btu combustible gas which can then be used in the same manner as natural gas with some modifications to the piping systems and burners on the existing boiler. Vol. 1 Sec. 7.4

Needless to say, this is a process with a great future because of the enormous number of gas and oil-fired furnaces in the country. A great deal of research has taken place in gasifying coal and wood and some prototype systems have been installed. However, very little research has been done on refuse gasification and no commercial systems have been developed. Therefore, refuse gasification is not recommended at this time.

CHAPTER 7

CENTRAL BOILER PLANT (Incr. E)

Reference

7.1 SCOPE

Increment E addresses the feasibility of installing a solid fuel-fired central boiler plant serving all or discrete parts of the post. Existing distribution systems are reused as much as possible. The analyses assume that all practical energy conservation measures developed earlier in this study will be implemented by the time the central boiler plants are built. The conclusions regarding load profiles and fuel sources presented in Chapter 3 and 5 are used. Economic analyses are based on the latest life cycle costing procedure as outlined in Engineering Technical Letter (ETL) 1110-3-332, Part 1. — Vol. 1 Sec. 8.1

The analyses include:

- Central Plant vs. Multiple Smaller Plants
- Solid Fuel Boiler Options
- Boiler, Fuel Handling, Pollution Control, Storage and Siting Recommendations.
- Central Distribution System layouts
- Building Equipment Retrofits necessary to convert to steam heating.

7.2 EXISTING HEATING PLAN

Sacramento Army Depot presently has 64 heated buildings on post, of which 21 are served by the existing central boiler plant and steam distribution system. The remaining buildings are served by individual heating systems. Table 7.1 summarizes the energy used in FY 82 and the estimated future energy usage. — Vol. 1 Sec. 8.2

Reference

TABLE 7.1

FUTURE FUEL REQUIREMENTS

	FY 82 Natural gas Usage (MB/yr)	Estimated Future Usage (MB/yr) (1)	% of Total Heating Energy	% of Total Heated Buildings
Boiler Plant	112,000	46,000	80	33
Individual Heating System	28,000	11,500	20	67
		57,500		

7.2.1 Boiler Plant

The existing central boiler plant contains 3-500 HP dual-fuel water tube boilers (old but fair condition) and 1-300 HP dual-fuel fire tube boiler (good condition). 80 psig steam is distributed to 21 buildings through approximately 6000 LF of underground line and 8,400 LF of overhead line (in warehouses). The primary fuel burned in the boilers is natural gas, however once a year #2 fuel oil is burned to insure that the dual fuel burners are operating satisfactorily. Vol. 1 Sec. 8.2.1

7.2.2 Individual Heating Systems

41 buildings have various types of gas-fired individual heating systems. Of these 41 systems, 4 utilize steam boilers, 2 use hot water boilers and 35 use direct fired furnaces, unit heaters or infrared heaters. Vol. 1 Sec. 8.2.2

(1) Assuming the energy measures of Increments A, B, and F reduce fuel consumption by 59%.

Reference

Table 7.2 shows six larger individual heating systems along with the FY 82 metered/estimated (M/E) natural gas usage. These 6 were isolated because they consume 38% of the energy used by individual systems and are relatively close to the existing steam distribution.

TABLE 7.2

INDIVIDUAL HEATING SYSTEM DESCRIPTION

Bldg	Boiler Type	No. & Size (KB/hr)	FY 82 gas usage(MB)	% of all individual Systems	Estimated Future Use(MB)
245	Steam	1-500	1119(E)	4	459
300	Steam	1-740	2103(M)	7	862
555	Steam	1-840	3099(E)	11	1271
650	Steam	2-1340	1456(M)	5	597
180	Hot Water	1-1000	2383(M)	9	977
680	Hot Water	1-360	460(M)	2	187
			10,620	38	4,353

7.3 PROPOSED FUEL SOURCE

Based on the conclusions of Chapter 5 the recommended primary fuel sources are on-post refuse, on-post waste, and off-post wood by-products. Vol. 1 Sec. 8.3

7.4 COMBUSTION EQUIPMENT ANALYZED

7.4.1 Central Boilers

Four types of boilers were investigated for the central boiler plant analysis: Vol. 1 Sec. 8.4.1

- Spreader-Stoker
- Suspension Burning
- Fluidized Bed
- Gasification

The results of the equipment analysis indicate that stoker firing offers a proven method of combusting coal and wood (the recommended solid fuels (see Chpt. 5). The technology has been

Reference

proven in service on a large number of units over a period of many years. Single units that have the capacity to meet the requirements of this project are standard models. The fuel handling and ash handling systems for the stoker-fired unit are the least complex of any alternative. No other system appears to offer any improvements over the stoker system in maintenance, operation costs or fuel costs.

Therefore, the stoker-fired conventional boiler is recommended for the new central plant boilers at SAAD. (see Fig. 7-1)

7.4.2 Individual Boilers/Furnaces

Individual boilers, where not recommended for centralization, were either converted to solid fuel or left as is. The criteria for conversion were: Vol. 1 Sec.8.4.4 Sec. 8.4.5

- capacity less than 600-700 KBH (see para. below)
- annual consumption at least 460 MB/yr
- estimated remaining life of boiler being converted at least 10 years

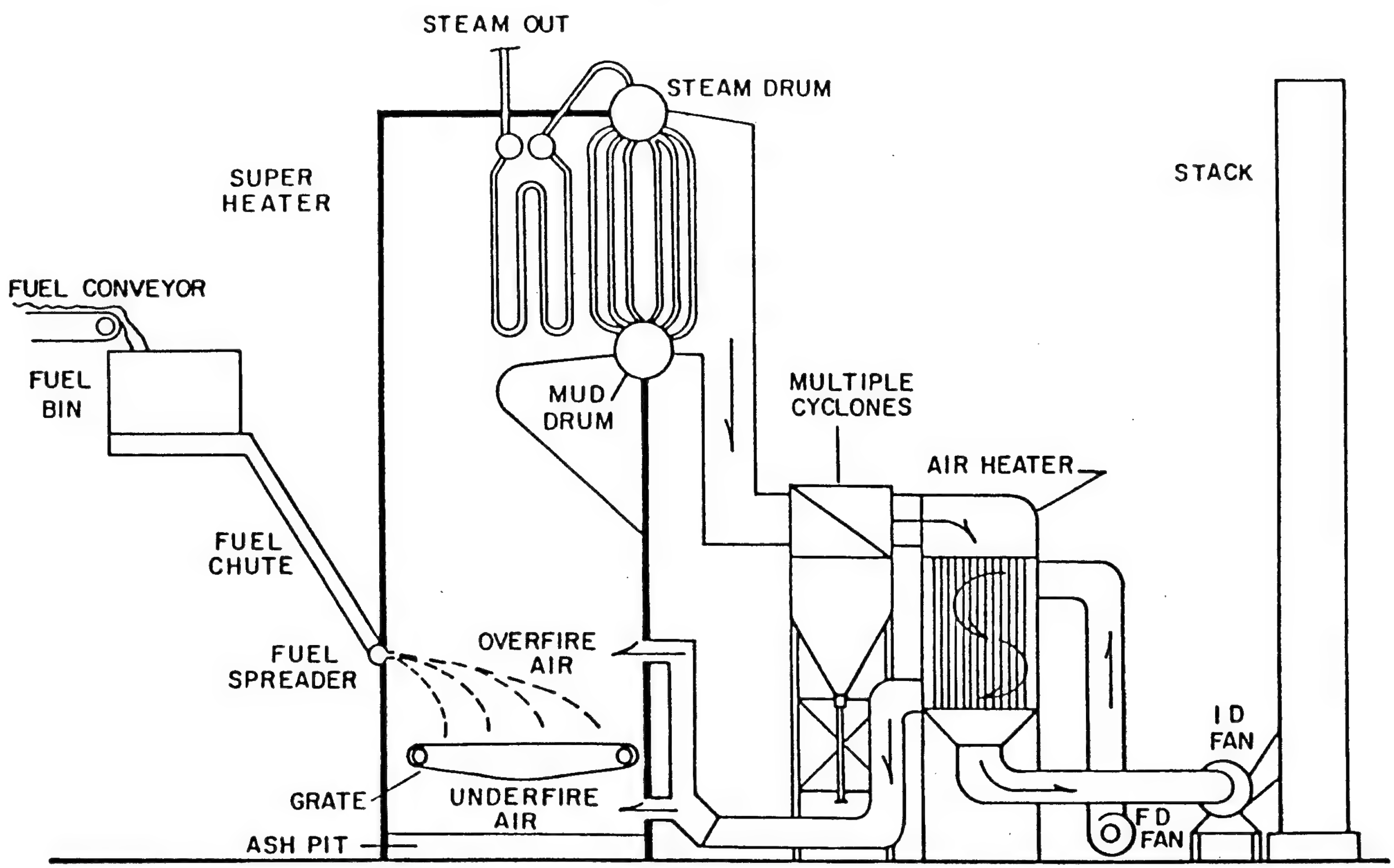
A solid fuel burner conversion system recently developed by Heat Harvester Corporation of North Carolina served as the basis for those systems recommended for conversion (see Fig. 7-2). It is the only burner retrofit found that has automatic solid fuel feed and modulating fire control. The system costs less than 1/3 the price of boiler replacement. At the time of this publication Heat Harvester offered only one size (600-700 KBH).

7.5 CENTRAL BOILER PLANT OPTIONS

Four options were analyzed for the proposed solid fuel boiler plant: Vol. 1 Sec. 8.6

Option 1: New Boiler plant serving entire post.

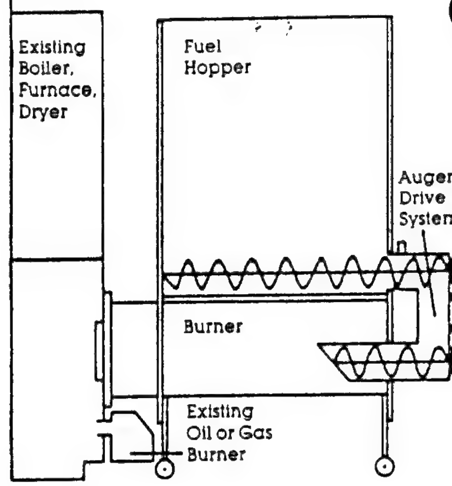
Option 2: New Boiler plant serving existing distribution system plus the six larger buildings that have individual



STOKER - FIRED BOILER

FIG. 7-1

TB 500
(Patent Pending)



Convenient

The TB 500 is an advanced solid fuel combustion system specifically designed for attaching to existing oil or gas fired furnaces, boilers, or dryers. In most applications the present burner is maintained for backup heat which is brought on automatically when the solid fuel supply is exhausted. Fuel is fed from an outside storage bin to the fuel hopper. From the hopper the fuel flows to the stainless steel burner where it is dried, gasified, then combusted. Ashes are removed within the burner so only the clean, hot gases enter the boiler or furnace.

- Automatic feed
- Automatic ignition
- Automatic switch to backup fuel
- Automatic ash removal
- High efficiency
- Low pollution, EPA tested
- Use present boiler, furnace, dryer
- Use present controls
- Long life
- Fast startup & shutdown
- 2-4 year payback
- Easy installation

Versatile

Dry wood chips

Green wood chips

Wood pellets

Wood cubes

Nut shells

Nut hulls

Grass pellets

Peat pellets

Paper waste cubes

Specifications

Output
300,000-600,000 BTU/h max.
10:1 turndown ratio

Dimensions
4' long x 3' wide x 6' high

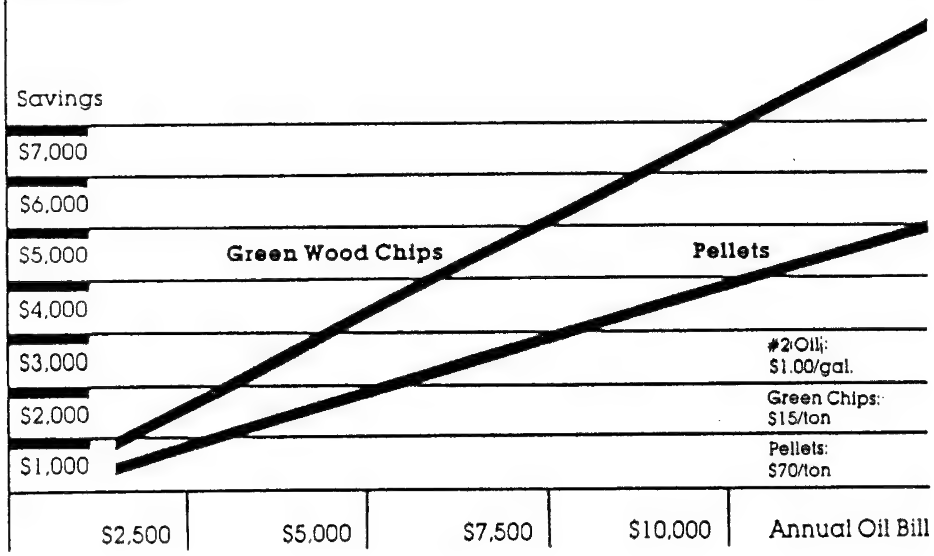
Weight
300 lb. (empty)

Electrical
110v, 20a

Safety
Timed burn-out
Split auger
Water sprinkler

Efficiency
Up to 88%, EPA tested

Economic



SOLID FUEL BURNER CONVERSION KIT

Heat Harvester Corporation
307 North Columbia Street
Chapel Hill, NC 27514
(919) 942-2007

FIG. 7-2

Reference

boilers (Bldg. 180, 245, 300, 555, 650, 680), leaving the smaller individual building heating systems as they are (natural gas).

Option 3: New Boiler plant serving existing distribution system, converting four of the six individual boilers to wood fuel and leaving all of the remaining individual building heating systems as they are.

Option 4: New Boiler plant serving existing distribution system and leaving all the individual building heating systems as they are.

Note that the first option maximizes the use of solid fuel, while each following option uses less solid fuel and more natural gas. These cases were analyzed to compare the relative cost of complete centralization versus various feasible combinations of central and individual plants.

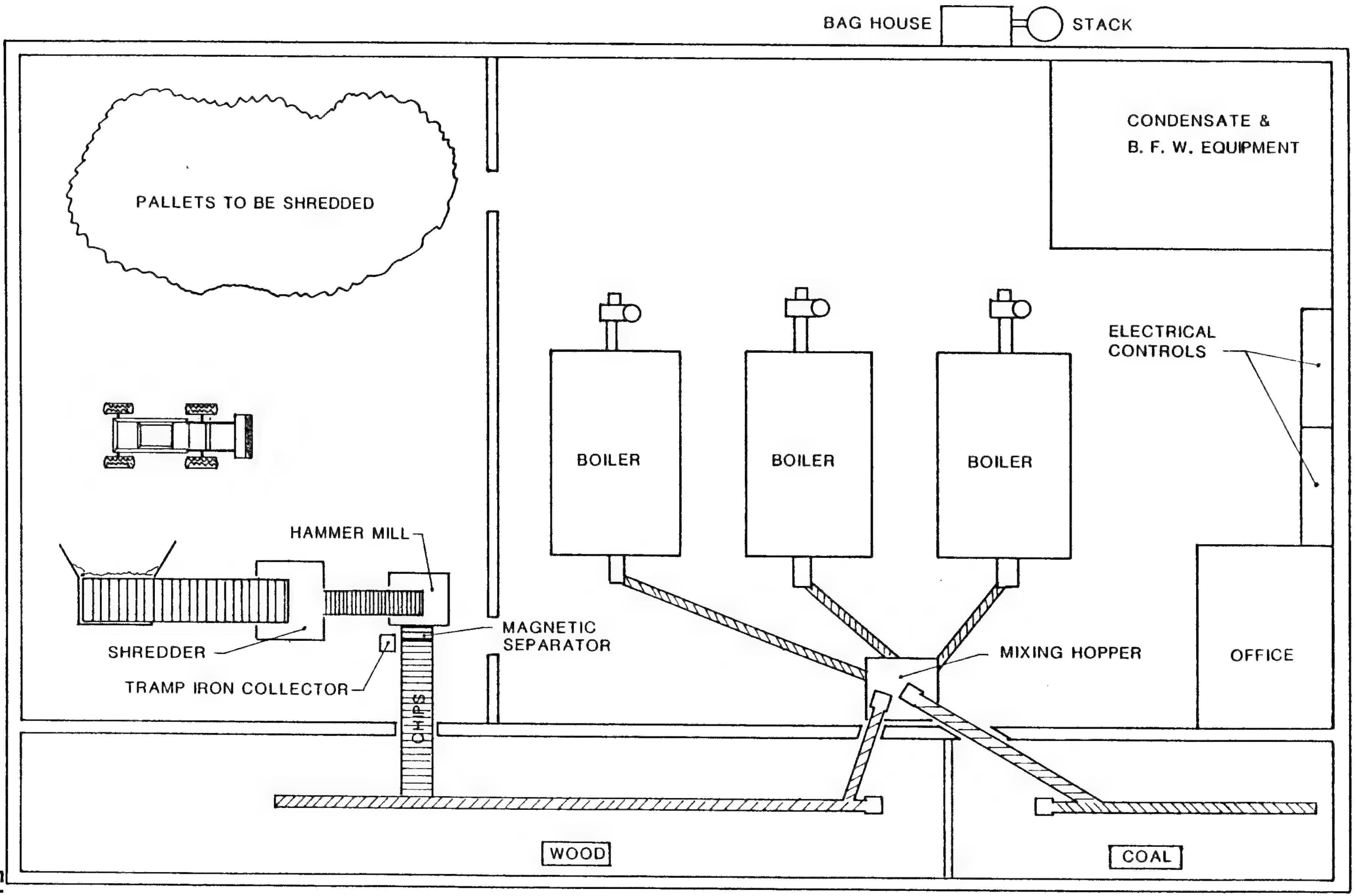
7.5.1 Emissions Compliance

Two forms of emissions exceeded the Sacramento County Emission Control standards, particulate matter (PM) and sulfur oxides (SOX). Baghouses are recommended for PM control. SOX is exceeded only during very cold weather and can be controlled by burning a greater percentage of wood which contains no sulfur. In all cases, these two measures were able to keep SAAD within the emission standards. Vol. 1 Sec. 8.5

7.5.2 Fuel Handling

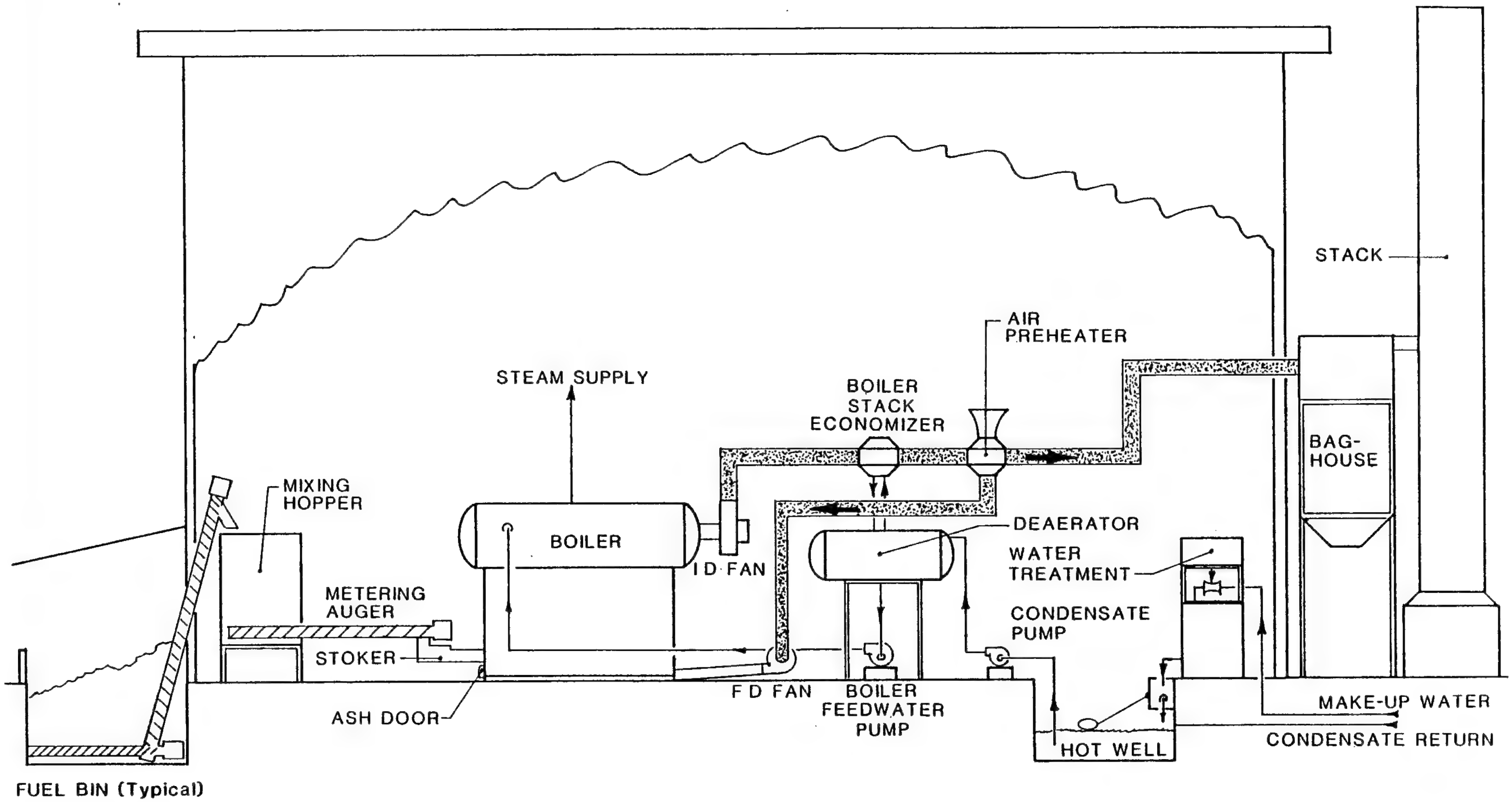
Fuel is assumed to be a mixture of wood chips and coal (see Chpt. 5). Coal would be delivered twice a year by rail, stored in a 1 year storage area near the railroad tracks, and transferred by truck and front end loader to the boiler plant 30-day storage area as needed. (see Figs. 7-3 and 7-4) Vol. 1 Sec. 8.6.1.3

Wood would be delivered by local suppliers as needed (14 trucks/month max. @ 25 Tons/load) and



SOLID FUEL HANDLING SCHEMATIC

FIG. 7-3



SOLID FUEL BOILER PLANT

FIG. 7-4

Reference

stored in a 30 day storage area near the boiler plant. Coal and wood would be delivered by SAAD personnel to the individual buildings which are not connected to the central steam distribution. Each building would have 7-day storage and automatic fuel handling.

7.5.3 Life Cycle Costs (LCC)

The four options were analyzed on a life cycle cost basis. Capital cost for new equipment, operating and maintenance costs, and fuel costs to heat the entire Post for the next 25 years were estimated for each option. Vol. 1 Sec. 8.6

The life cycle costs are based on the present worth analysis method. In other words the costs indicated are the amount that would have to be invested in FY 83 dollars to pay all system costs for the next 25 years.

Several assumptions are implicit in this analysis, i.e. the cost of money, fuel price inflation, operating and replacement costs, and labor rates. A complete listing of the assumptions can be found in the reference quoted at the right.

7.5.4 Conclusions

Option 1 displaces 99% of petroleum-based fuel on the Post but has the highest LCC (see Table 7.3). Option 4 has the lowest LCC and displaces 80% of the petroleum-based fuel. The LCC of Option 3 is 1% higher than Option 4, however 3 displaces 5% more petroleum-based fuel. Vol. 1 Sec. 8.6.5

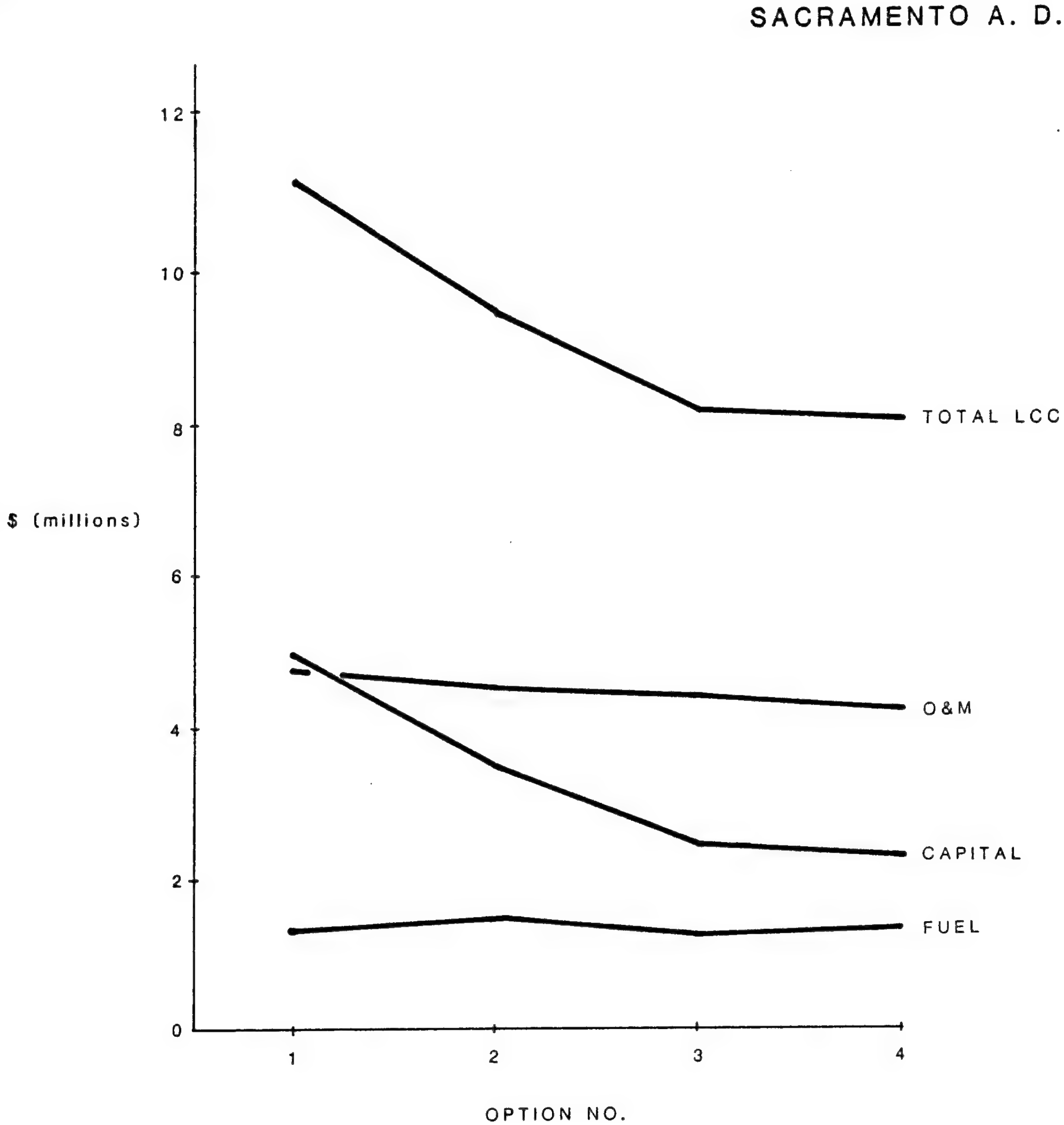
Fig. 7-5 indicates the relationship of the various cost factors for each option. The capital cost of the boiler plant and individual building modifications is the dominant factor in the life cycle costs.

The fuel costs remained fairly constant between the four Options. The higher fuel costs due to increased fossil fuel usage in Options 3 and 4 were negated by the higher distribution losses in Options 1 and 2.

TABLE 7.3

SUMMARY OF CENTRAL PLANT LIFE CYCLE COST ANALYSES

	Life Cycle Cost (K$)	Capital Cost (K$)	Maint. Cost (K$)	Oper. Cost (K$)	Solid Fuel Cost (K$)	Natural Gas Cost (K$)	Total Fuel Cost (K$)
Option 1 New Solid Fuel Plant serving entire post	11,216	5,058	2,496	2,344	1,339	0	1,339
Option 2 New Solid Fuel Plant serving existing + 6 largest indiv. systems	9,528	3,529	2,216	2,344	1,013	426	1,439
Option3 New Solid Fuel Plant serving existing systems & 4 indiv. boilers converted to solid fuel	8,185	2,432	2,065	2,425	743	520	1,263
Option4 New Solid Fuel Plant serving existing system	8,107	2,369	1,982	2,382	688	686	1,374



GRAPH OF CENTRAL PLANT LIFE CYCLE COSTS

FIG. 7-5

Reference

The operating and maintenance (O&M) cost remained relatively constant from option to option. The labor savings from reducing the number of boilers (Option 1) is offset by the increased labor to properly maintain the steam distribution system.

7.6 RECOMMENDATIONS

Option 3 will displace 49,000 MB/yr of natural gas (85% of the future heating requirements of the post) at a capital cost of $2,432,000 and a life cycle cost of $8,185,000. If this project is judged on the basis of economics with natural gas displacement being of secondary importance, this option offers the best return on investment. However, if fossil fuel displacement is the primary goal, with economics being of secondary importance Option 1 should be implemented. Option 1 will displace 57,000 MB/yr of natural gas (99% of the future heating requirements for the post) at a capital cost of $5,058,000 and a life cycle cost of $11,216,000. Vol. 1 Sec. 8.6.5

CHAPTER 8

BASEWIDE ENERGY MASTER PLAN

8.1 OVERVIEW

The purpose of the Energy Engineering Analysis Program (EEAP) is to aid SAAD's Commanding Officer in developing a Basewide Energy Master Plan in concert with the objectives of the Army Facilities Energy Plan published 26 October, 1981 by the Office of the Chief of Engineers. The EEAP addresses energy conservation in facilities and conversion to non-petroleum fuels. When combined with the Commanding Officer's plan for energy reduction in all other non-facility areas, i.e. transportation, it will provide the basis for the Basewide Energy Master Plan. This chapter presents a summary of the following:

1. Army Facilities Energy Goals as outlined in the Army Facilities Energy Plan.

2. SAAD's present and projected future status with regards to the facilities and critical fuel portions of the Army Facilities Energy Goals.

3. Long-range plan for the implementation of each of the energy conservation and fuel conversion measures recommended in the EEAP.

8.2 ARMY FACILITIES ENERGY GOALS

The Army Facilities Energy Plan sets energy goals for FY 85 and FY 2000 for individual facilities. These goals have been edited to fit SAAD and are summarized below. A complete copy of the goals is included in the Appendix of Volume 1.

8.2.1 FY 85 Goals

Reduce total facilities energy consumption (Btu's) by 20% relative to energy consumption in FY 75.

8.2.2 FY 2000 Goals

A. Reduce total facilities energy consumption (Btu's) by 40%.

B. Develop the capability to use synthetic gases.

C. Reduce heating oil consumption by 75%.

8.3 SAAD STATUS REGARDING ENERGY CONSERVATION

8.3.1 FY 85 Goals

SAAD's facilities energy usage during FY 75 was 388,700 MB's thereby initally establishing the FY 85 goal at 310,900 MB's. In February 1983 the goal was adjusted to 345,000 MB due to increased missions/workload requried of SAAD. A request for an additional increase in the goal is expected to be submitted in mid FY 84.

In order to project energy usage as affected by the Energy Conservation Opportunities recommended in the EEAP, it was assumed that SAAD would be able to expend approximately $100,000 per year on projects contained in Increment F based on guidance from Mr. Frank Moran, SAAD Facilities Services Manager. Projects would be funded beginning in FY 84 through FY 91 with the energy saving for each project begining in the eyar following funding. ECIP projects are scheduled for funding in FY 87 and will not impact on energy usage prior to FY 88.

We project that SAAD will exceed its energy reduction goal by 1% (usage-342,128 MB: Goal-345,000 MB) by FY 85, (Fig. 8-1) if the Increment F ECO's are implemented according to the schedule indicated in section 8.5, Implementation Plan.

These estimates are based on SAAD's known energy usage for FY 83 and does not account for increases in mission, changes in processes resulting in incrased energy use, etc. Because the projected usage is so close to not meeting the FY 85 goal, it is imperative that SAAD's Energy Coordinator be kept abreast of any planned

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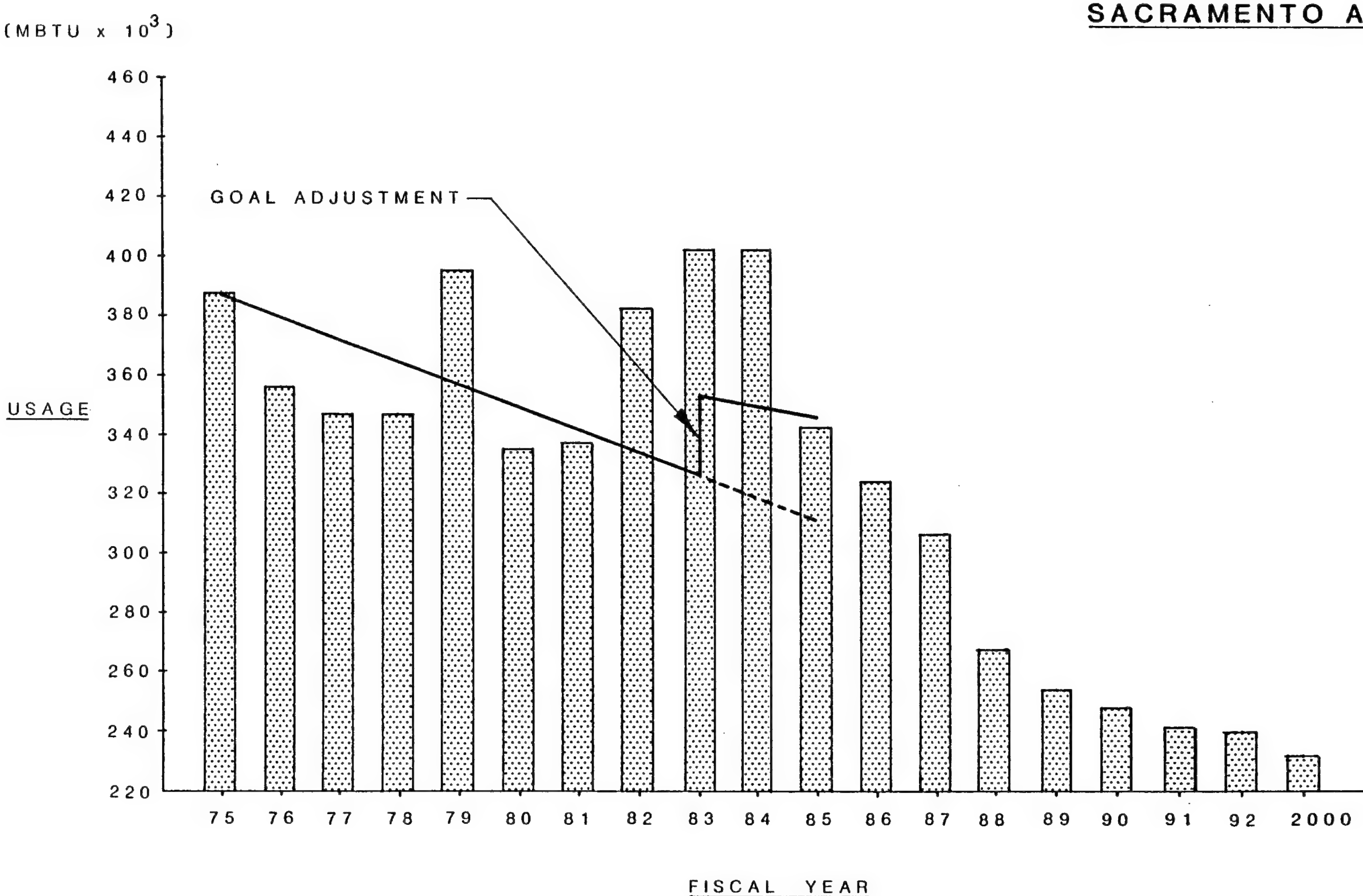

ENERGY USAGE

FIG. 8-1

change in mission or the addition of any using equipment so that the Commander can be given a timely estimate of its impact on the depot's energy usage.

8.3.2 FY 2000 Goals

Two projects for ECIP funding were identified in the EEAP (see Executive Summary, Chapter 3). These projects are scheduled for FY 87 funding. These two projects, combined with the projects identified in Increment F, will fall short of meeting the FY 2000 goal by 2% (38% total reduction).

Several buildings are targeted for replacement by Fy 2000 (see Increment F, Table 2.6). This will increase SAAD's gross building area by 1.74 million square feet and increase SAAD's energy consumption by 11% relative to FY 75 energy consumption. Additional adjustments of the goal will be needed to account for this increased building area and mission.

8.4 SAAD STATUS REGARDING HEATING OIL CONSUMPTION

Currently nearly all of SAAD's space heating requirements are met through the use of natural gas.

The EEAP concludes that the following non-petroleum fuels are readily available to SAAD.

- on-post refuse and waste (pallets and packaging materials)
- off-post wood byproducts (from local manufacturers)
- off-post wood chips (from forest and agricultural residue dealers)
- coal

Two projects from Increments C, D, and E are recommended for implementation at SAAD in FY 87. The two projects are summarized below.

Solid Fuel Boiler Plant: Construct new wood/coal/oil/gas boiler plant to serve the existing steam distribution system. Convert gas fired boilers in 4 individual buildings to solid fuel. Use boilers to supplement the incinerator with heat recovery boiler system.

Incinerator With Heat Recovery Boiler: Install one incinerator with heat recovery boiler in the proposed solid fuel boiler plant. The system will be capable of burning all on-post waste and refuse thus reducing purchases of solid fuel for the backup solid fuel boilers and reducing garbage disposal costs.

These two projects will exceed the FY 2000 goal by 10% (85% fossil fuel reduction).

8.5 SAAD STATUS REGARDING CAPABILITY TO USE SYNTHETIC GAS

The cost of synthetic gas will not be competitive with the cost of solid fuel so that the only possible application will be for the individual building heating systems. These small systems are widely separated and use 15% of the post space heating fossil fuel. The modifications that would be required to use synthetic gas include:

- Replace existing natural gas distribution system with larger diameter pipes due to the lower energy content of synthetic gas (1000 Btu/cf for natural gas vs. 150-500 Btu/cf for synthetic gas)
- Boiler burner modifications to accept a higher flow of gas.
- Locate a competent supplier of synthetic gas.

It is felt that it is too early to analyze the impact of this option at SAAD due to the fact that there are no synthetic gas suppliers in existance and it will be at least ten years before an infrastructure will begin to develop.

8.6 IMPLEMENTATION PLAN

8.6.1 Schedule

Fig. 8-2 indicates the projected schedule for implementing the energy projects recommended in the EEAP. It assumes receipt of funding for the 2 ECIP projects (EMCS, Boiler Replacement) - see Chapter 3) in FY 88. It further assumes expenditure of $100,000 per year of O&M funds for the O&M projects (Increment F) to be completed over the next 8 years (FY 84-91).

8.6.2 Costs & Manpower

All project costs include funds for design, supervision, overhead, profit and construction by private contractors. Therefore no additional manpower is required for any of the energy conservation construction.

The EMCS and solid fuel plant conversions will require additional maintenance staff. Since the EMCS is a one-way FM system used only for on-off control it requires a total of 1 manday per week for operating and maintenance (see Table A-5.1 and A-5.3, Appendix 5, Volume 1). The new solid fuel conversions will require an additional 1.5 man-years per year to properly operate and maintain the systems including fuel handling. Therefore, the two new systems, EMCS and solid fuel heating plants, will require 2 additional maintenance personnel.

FIGURE 8-2

ENERGY CONSERVATION PROJECT SCHEDULE

PROJECT DESCRIPTION — **FISCAL YEAR / COST** (84 85 86 87 88 89 90 91 92)

INCREMENT F

PROJECT DESCRIPTION	COST
REDUCE STEAM PRESSURE, BLDG. 352	$237
REDUCE RUN TIME OF SHRINK MACHINE, BLDG. 242	0
REDUCE EXHAUST/OSA VENTILATION, BLDG. 150	188
REVISE T-STAT SETTINGS, VARIOUS BLDGS.	5630
PLASTIC DISCS ON DIP TANKS, BLDG. 420	715
CLOSE OSA DAMPERS AT NIGHT, BLDG. 150	120
INSULATE PIPING & EQUIPMENT, VARIOUS BLDGS.	1201
REDUCE EXCESS AIR/BOILER TUNEUP, BLDG. 352	9900
REPLACE CONDENSATE EQUIPMENT, BLDG. 352	8792
REDUCE EQPT. RUN TIME-BOQ HV UNIT, BLDG. 140	263
REPAIR ECONOMIZER, BLDG. 245	1018
LOWER D.H.W. TEMPERATURE, VARIOUS BLDGS.	714
REDUCE EQPT. SIZE-BOILER, BLDG. 245	4899
NIGHT SETBACK & ZONE CONTROL, BLDG. 150	10363
TIMECLOCK/NIGHT SETBACK, BLDG. 555	7933
REDUCE REHEAT, BLDG. 555	12916
D.H.W. RECIRCULATION PUMP CONTROL, VARIOUS BLDGS.	58
TIMECLOCK/NIGHT SETBACK, VARIOUS BLDGS.	119416
SHUT DOWN SUMMER STEAM	17618
ECONOMIZER/REDUCE OSA, BLDG. 300	9318
BOILER STACK ECONOMIZER, BLDG. 352	81619
TIMECLOCK/NIGHT SETBACK, BLDG. 300	1652
DELAMP, VARIOUS BLDGS.	6866
INFRARED HEATING, BLDGS. 330 & 439	10450
TIMECLOCK CONTROL OF LIGHTS, BLDG. 150	8141
INSULATE WALLS, VARIOUS BLDGS.	60973
REDUCE REHEAT/CONVERT DX TO CHW SYSTEM, BLDG. 300	21546
REDUCE EQPT. RUN TIME-ADD LOUVERS, BLDG. 245	30152
ECONOMIZERS, BLDG. 245	43948
DHW TANK INSULATION, VARIOUS BLDGS.	2943
ADD/REPAIR HVAC ECONOMIZERS, VARIOUS BLDGS.	665
D.H.W. FLOW RESTRICTORS, VARIOUS BLDGS.	9661
INSULATE ROOFS, VARIOUS BLDGS.	2800
CONVERT TO COOLING TOWER, BLDG. 245	27434
REPLACE LIGHTING FIXTURES, VARIOUS BLDGS.	26335
INSULATE DIP TANKS, BLDG. 420	29641
REPLACE LAMPS, VARIOUS BLDGS.	215
PHOTOCELL CONTROL OF LIGHTS, VARIOUS BLDGS.	73399
REDUCE HW CIRC. PUMP OPERATION, BLDG. 680	80
WEATHERSTRIPPING, VARIOUS BLDGS.	85109
PLASTIC DOOR CURTAINS, VARIOUS BLDGS.	44363
MANUAL TIMER ON LIGHTS, VARIOUS BLDGS.	1088

INCREMENT A & B

PROJECT DESCRIPTION	COST
ECIP PROJECT TO INSTALL EMCS	232,364
ECIP PROJECT TO REPLACE CENTRAL PLANT BOILERS	748,659

NOTE: PROJECT COSTS IN FY 83 DOLLARS